FAO. Fisheries Biology Technical Paper

LIBRARY
FEB 12 1962
FISH & WILDLIFE SERVICE

FISHERIES RESOURCES OF THE EAST COAST OF AFRICA AND THE CENTRAL INDIAN OCEAN

by

H. Rosa, Jr. and T. Laevastu
FAO, Fisheries Division, Biology Branch.

LIBRARY
BUR. OF COMM. FISH.
HON. BIOL. LAB.

FAO, Rome July, 1960

LIST OF CONTENTS

		Page
1.	Introduction	1
2.	The coast and continental shelf	2
3.	Maritime meteorology and fishing conditions	2
4.	General hydrography and marine biology	4
5.	Occurrence and distribution of commercial species	5
6.	Present exploitation	5
7.	Estimates of standing crops of resources in the area and possibilities for expanded exploitation	5
8.	The tuna resources of the Indian Ocean	9
Tables I - XII		11-28
Figures		
Appendix:	Selected bibliography on the oceanography and marine biology of the Indian Ocean.	

1 INTRODUCTION

A paper entitled "The Present Status of Knowledge of the Living Resources of the Marine Waters of the West Coast of Africa" was presented by FAO to the C.S.A. Symposium on Oceanography and Sea Fisheries on the West Coast of Africa, Luanda, 21-27 November 1957. It explained that the Fisheries Biology Branch of FAO had begun a programme systematically to produce drafts of Regional Synopses of data on living aquatic resources of economic value in different areas, as part of an appraisal of knowledge about those resources, on a world-wide scale.

Work carried out by some of the institutions in the area being considered by the present meeting is similar in aim to that being conducted by FAO. Thus the Mauritius-Seychelles Fisheries Survey, the Preliminary Survey of the Pelagic Fishes of East Africa, the Preliminary Survey of the Hydrography of the British East African Coastal Waters and the Exploratory Fishery Survey carried out in Somalia by a team of FAO fishery workers, produce by field work the type of information required for the knowledge of the resources and their relation to the environment. The appraisal being developed by the Biology Branch, on the other hand, is a bringing together of these and other types of information from many waters, to be eventually collated in an Atlas of the exploited and potential living aquatic resources of the world. This is being done not only to take stock of the present knowledge, but also to evaluate the current extention of exploitation of the resources and the possibilities of further expansion or need for controlled exploitation, depending on each particular situation.

Although the species being caught commercially are the subject of primary interest, data about their environment is also brought together with a view to understanding their behaviour and by comparison predicting the existence of other potential resources.

The note here presented should, when revised (with the collaboration, it is hoped, of the fishery scientists in the area) give a synoptic account of the resources and of the environment of the area and together with a revision of the paper prepared for the Luanda meeting, will comprise an account of the fishery resources of the oceanic coasts of Africa. We give a brief discussion of the types and magnitudes of the marine fisheries resources of the area and a condensed summary of the environmental factors which affect the magnitude and may determine present and future exploitation of these resources.

Relatively few data are available, however, and therefore several prognoses given are based on the knowledge and experience of other oceanographically similar areas. The maps cover the entire Indian Ocean and the selective bibliography on the oceanography and marine biology of the Indian Ocean contains references pertinent to the subject under discussion.

This paper is a first attempt to summarise the basic known facts concerning the oceanography and living aquatic resources of the region. Its purpose is to display a line of argument intended to lead to some conclusions concerning the potential of the resources. Available data are - so far as we have been able to appraise them - rather significant for certain areas (northern Somalia, Kenya, Tanganyika and Mauritius-Seychelles Arch) but too scanty for the remaining areas to permit any conclusions for the whole region and for adjacent areas, such as the Arabian Sea and the waters west of Australia.

It is hoped that during the meeting new findings and data will be brought up for discussion which will be considered in the revision of this draft. It is also expected that the planned International Indian Survey will greatly contribute to the knowledge of the area.

2 THE COAST AND CONTINENTAL SHELF

The approximate extent of the continental shelf (0 to 200 m), nature of its bottom and nature of the coast are shown in Figure 1. The areas, average depths and other characteristics of larger continental shelves in the Indian Ocean are given in Table I.

The coast of Good Hope Province is inhospitable, rocky and high; the numerous small rivers are fronted by sand bars and there are five ports available along it. The coast of Natal is as bad or even worse in these respects than the coast of the southern province and landing on the Natal coast is extremely difficult and dangerous at most times. The only good harbour available is Durban. The rivers Umkamaso and Tugela are navigable for small craft for a short distance.

The coast of Portuguese East Africa, southward of Mozambique is low, sandy and lined with mangroves. There are few and poor harbours and landing on the coast is difficult and dangerous. The coast northward of Mozambique is considerably indented, has rocky headlands, rugged cliffs and an almost continuous fringe of islets which afford protection for landing. Some of the rivers are navigable for a considerable distance. There are ten satisfactory ports along this coast.

The coast of Tanganyika Territory and Kenya is generally low and composed of coral, partly covered with sand, dense bush or mangroves, and is little indented. The rivers are, in general, shallow, except Tand, Kilifi and Matapwa, which are navigable for small craft a few miles from the entrance. The only good port on the Zanzibar coast is Zanzibar. In Tanganyika Territory, the principal port is Dar es Salaam and in addition there are seven smaller ports. On the Kenya coast the principal port is Mombasa, but there are also a number of other smaller ports.

The coast of Somaliland to Cape Guardafui is straight and rocky, without any good harbours. Besides the harbour of Kisimayu, there are only a few open anchorages.

The west coast of Madagascar is very irregular, with numerous banks and small islands, but without vegetation. The east coast is of coral lime, and has very few landing possibilities.

The Laccadive and Maladive Islands and the Chagos Islands are coral reefs. The Seychelles, Mauritius and Union Islands are higher, with heights up to 900 m.

3 MARITIME METEOROLOGY AND FISHING CONDITIONS

The resultant direction and force of the winds and the percentage of moderate gales and stronger winds in the Indian Ocean area during the months of February and July are shown in Figures 2 and 3. As Figure 3 shows, nearly all kinds of fishing are extremely difficult or impossible off the NE coast of Somalia during July and August. This season is, however, the most naturally productive in this area, because of the upwelling which occurs along the Somali

coast during the northern summer. There is also a relatively high frequency of high winds throughout the year in the Mauritius Islands, Nazareth Banks area.

Monsoons do not occur south of Mozambique. South of the equator the monsoon winds from north to east prevail from August to March inclusive. During April, the winds shift to southeast and continue between east and south until July. Going northward along the coast, monsoons are stronger and more regular.

Around the equator and north of it, the monsoon wind is northeast in the northern winter and becomes variable in March. In April, the wind is changeable, generally between southeast and southwest. By May, the prevailing wind is southerly and continues until September. At the end of September or in October the wind shifts to southeast where it prevails until December. The northeast monsoon becomes established in December.

From Mozambique to Durban the prevailing winds off-shore are south-easterly in all seasons. Opposite to Madagascar, and north and south of it, the winds are mostly on-shore, or more or less parallel to it. The land and sea breeze is experienced in several parts of the southern coast of Africa and Madagascar, reaching a few miles out to sea. The influence of cyclonic storms on the southern South African coast is marked in the winter.

The typical tracks of the tropical storms in the Indian Ocean area are shown in Figure 4. Cyclones of the south Indian Ocean are generated between 5° and 15° S latitude east of Rodriguez Island. The majority of those storms recurve over the ocean between 15° and 22° S and between 50° and 60° E. Average speed of progression is about 8 to 9 m.p.h.

The islands Mauritius, Union and Rodriguez lie directly in a path frequented by numerous cyclonic disturbances during January, February and March, making the off-shore fishery in the area hazardous during these months.

The climate is tropical along almost the entire coast. On the coast of the Cape of Good Hope Province, the summer lasts from November to April. Mean air temperatures are: February 67° F and July 52° F. Westward of Cape St. Francis, winter is the rainy season. Eastward of this Cape, summer is the rainy season. The annual rainfall on the east coast increases towards the north. From Cape Town to Great Fish Point, fog occurs from March to August.

The wet season on the Natal coast is from October to February, but some rain occurs also in other seasons.

The coastal climate of Portuguese East Africa is extremely hot and moist. The cooler season of the coast is usually from April to August, and the rainy season from December to March. At Delagoa Bay, the rainy season starts in September and at Mozambique in November.

Coastal regions of Tanganyika are warm and damp. There are two well defined rainy seasons. The long rainy season starts in February or March and lasts for two to three months. The short rainy season is in October and November.

The temperature on the Zanzibar coast during the coolest months, from July to September, is about 82° F at noon, falling to 73° F at night. From January to March the temperature is

about 88°F at noon. The season of heavy rains is from March to May, and the lesser rainy season from November to December. The rainy season on the Kenya coast commences in April and ends in November.

On the Somalia coast, the year is divided into four seasons of about three months each, starting from the middle of August; namely: (1) Der, in which the rainy southwest monsoon still prevails until the northeast winds set in; (2) Jilal, the dry season, with constant northeast winds; (3) Gu, the wet season, in which the northeast winds prevail until the southwest monsoon sets in; (4) Agai, the hot season with lesser rains at intervals, in which the southwest monsoon is constant.

4 GENERAL HYDROGRAPHY AND MARINE BIOLOGY

Knowledge of the hydrography and especially of the marine biology of the east coast of Africa is very sparse. A general picture can, however, be constructed on the basis of data collected by several expeditions which have crossed the area (see Figure 5).

The surface temperature and currents during February and August are shown in Figures 6 and 7. It is apparent that the east coast is under the influence of the equatorial current system all the year round; only in the northern part is it influenced by monsoon currents, which in this part have a character similar to that of the north equatorial current. Warm, biologically poor, surface waters are anstaued along almost the entire coast throughout the year.

The Somali Current has considerable seasonal variations, being most developed during the SW monsoon. The main current is limited to a relatively narrow strip off the continental slope. Upwelling occurs during the SW monsoon in several places, especially around Roshaven. Here, the oxygen minimum layer is occasionally brought to the surface so that the sea smells and maybe is coloured olive green, because of the high organic production.

The Agulhas Current in the south varies much less in volume, strength and direction through the year than the Somali current.

Counter clockwise eddies are often formed between the southwest and northwest coasts of Madagascar and the eastern edge of the Mozambique current. No upwelling effects of these eddies have yet been reported.

The tropical subsurface oxygen minimum layer, which is very pronounced and close to the surface in the Arabian Sea, reaches along the east coast of Africa to about 35°S, being less developed (oxygen content 2 to 3 ml/L) and slightly deeper (100 to 200 m) in the south than it is north of the equator (see Figure 8).

The knowledge of the distribution of nutrients and basic organic production along the east African coast is very limited. Judging from the few available measurements and from the prevailing hydrographical conditions, the basic organic production in these waters is very low; exceptions are the northern coast of Somalia, where upwelling occurs during the SW monsoon (mainly from June to August inclusive) and possibly in two very limited locations west of the south and north tips of Madagascar and limited offshore divergence zones in the equatorial current system, especially where those divergences are close to the offshore grounds. Some

higher production may also be found on the slopes of offshore banks (e.g. Nazareth Banks) where a mixing of deep and surface water is expected. Very limited areas of higher basic organic production can also be found off the river mouths.

Very low standing crops of zooplankton have been found along the East African coast, the bulk of zooplankton being below 100 m. Somewhat higher zooplankton standing crop has been found in the area of equatorial current between Madagascar and Ceylon.

Almost nothing is known about the standing crop of benthos on the East African coast. One would expect it to be low - as in most tropical areas - and limited to shallow water, because of the effects of the subsurface oxygen minimum layer. Exceptions to this rule can be expected (a) off the river mouths where bottoms are suitable and where more organic matter is available in the bottom, and (b) on the slopes of offshore banks swept by currents. The standing crops of fish are discussed in Chapter 7

5 OCCURRENCE AND DISTRIBUTION OF COMMERCIAL SPECIES

In Figures 12 to 17 the occurrence of the species of fish caught commercially or during exploratory fishing have been plotted, and in Tables III, IV and V a register of those species has been prepared giving available relevant biological and fisheries data compiled from various sources, particularly from Wheeler and Ommanney (1953), Williams (1956), FAO (1954), Smith (1949) and Petit (1930).

It may be noticed that most of the species caught or of potential value are common to the whole area under consideration.

6 PRESENT EXPLOITATION

Statistics for catches and landings of marine fishes in East Africa are given in Table VI, and their conditions of exploitation are indicated in Tables III, IV and V.

7 ESTIMATES OF STANDING CROPS OF RESOURCES IN THE AREA AND POSSIBILITIES FOR EXPANDED EXPLOITATION

From the maps (Figures 12 to 17) it may be noted that a number of species which are of considerable economic value in other region, such as tunas and mackerels, sardines, groupers, jacks and snappers, occur also in these waters. The total marine production in the area in 1956 when statistics were available for most of the countries and territories excluding South Africa was, however, only 121.2 metric tons (Table VI), which is, in comparison with other parts of the continent (e.g. West Africa) or of the world, very low.

The questions of immediate interest are:

(1) Can the stocks of the various species sustain higher catches and, if so, how much higher?

(2) Are any resources or potential fishing areas neglected and, if so, why?

Partially to find the answer to these questions the following notes on the marine resources of the eastern Indian Ocean and the apparent possibilities for future exploitation have been arranged by natural regions (see Figure 9). Some pertinent monthly average environmental conditions in these regions are summarized in Table II.

The Somali waters

The Somali waters facing the Indian Ocean have a narrow continental shelf, and few harbours large enough only for the smallest vessels. The subsurface oxygen minimum layer has an unfavourable effect on the standing crops of benthos and of demersal fish.

During the SW monsoon, June to September, the strong winds (reaching at times 60 m.p h. and the sea and swell make fishing with small local craft virtually impossible. The turbidity of the water is high and decreases the efficiency of hook and line fishing. On the north coast, however, during the fishing season from September to May - during which months there are only relatively light winds of the northeast monsoon - Arab fishermen have been catching sharks, tuna and other fish. On this coast the continental shelf is very narrow and a large number of oceanic species is within reach of the local dug-out canoes and small boats propelled by paddles or sails.

An FAO mission from whose report the information here given was extracted, worked in that area to improve tuna fishing methods and explore the tuna resources with a small tuna-clipper

In Table VII the analysis of the catch by species is given.

The Mission experimented with a variety of gears for bait-catching, trolling longlining and pole fishing from the tuna-clipper and from local boats. Multiple-trolling, bait-catching techniques and keeping the bait alive proved successful as well as modifications of local fishing craft which were successfully tested with outboard motors.

It is apparent that the improvement of fishing techniques and local fishing boats as well as investments on modern larger boats like tuna-clippers would increase production and help expand the fishery eventually to the Arabian Sea where pelagic species are relatively abundant.

The Kenya, Tanganyika, Zanzibar waters

Species of about eight families of surface or mid water fishes and five of bottom fishes have been caught in these waters commercially or experimentally. Williams (1956) made a preliminary survey of the pelagic fishes mainly using multiple trolling for their capture. The following results have been extracted from his report.

The total catch of fish from November 1951 to January 1954 was 8, 635 lbs. Of this total 7 803 lbs were caught at trolling speed in 6, 822 line hours giving a catch rate of 1. 12 lbs/line/hr. The remaining 832 lbs were caught at full speed whilst on passage, a catch rate of 0. 22 lbs/line/hr.

The total weight of fish was represented as shown in Table VIII.

In Table IX the different sections of the area surveyed are listed in order of catch rate.

As a result of his survey Williams (1956) concluded that although the average catch rate for multiple trolling was comparatively low the pelagic fishery in the waters studied is capable of considerable expansion by the introduction of specific trolling methods among the native fishermen, and by exploitation of grounds not then being fished.

Central Indian Ocean offshore islands and banks

The best report available to date on the offshore fishery resources in the Indian Ocean is that of Wheeler and Ommanney (1953) on their Mauritius-Seychelles Fisheries Survey 1948-1949. The extracts which follow are taken from that report.

Wheeler at the time of his survey of the demersal fishery resources of the banks of the Mauritius-Seychelles area wrote "that no increase of any size in production can be secured by increasing the fishing effort. All that can be taken from the inshore waters is being taken. Greater intensity - more traps and more nets - would mean a lessened yield for each".

About the Seychelles he wrote: "Reading of the Seychelles gives an impression of an immense area of fishable water, containing fishes in number far exceeding the needs of the human population on the relatively small areas of land. The Seychelles fisherman will take his craft without hesitation to places only just within sight of land where the second part of this impression appears an understatement; but he is in fact on one of the well known banks at the edge of the plateau and has sailed over many miles of sterile bottom to get there. The plateau of 10,000 sq. miles of productive water is an illusion. The fish are concentrated at the periphery and even there the distribution is not uniform. While, therefore, expansion of the existing fishery appeared practicable, the extent of such expansion was at the time unknown".

Demersal fish

The area investigated during the survey covered all the dependencies of Mauritius and Seychelles including Chagos Archipelago, off Rodrigues, Hawkins bank, Aldabra Islands, Farquhar group with Province Islands, the Agalega Islands, Cõetivy and Platte Island. It was found that the edges of the banks fall abruptly to great depths and that the only fishable waters are on the banks themselves, found near the centre and rarely exceeding 60 fathoms.

Generally no heavy catches were made in less than 8 or more than 32 fathoms. The most productive depths were between 10 and 18 fathoms with coral bottom. Fishing in waters deeper than 32 fathoms except in some localities was unproductive. In regard to bottom fishes, no emigration or immigration of the species was registered. Each bank is an isolated unit. Wheeler (in Wheeler and Ommanney 1953) calculated an assessment figure for each bank or locality using the weight of the catch, the fishing time and the average number of lines. He further analyzed the figures separately as weight of fish and weight of sharks in tons (avoirdupois) per man per year (single line for a year of 240 days of six hours each). The results with the calculated fishable area, the fishing time spent in each locality, and the total weights of fish and sharks are given in Table X.

The actual fishing time during the survey was 285 hours 35 minutes; and the total catch was 39,770 lbs of fish, and 48,870 lbs of shark. The overall rates in tons (avoirdupois) per man per year's work were 18 for teleost fishes and 21½ for sharks. For comparison with commercial rates of fishing in other areas these figures were expressed as weight in cwts per 100 hours by one line.

Using the figures of quantities caught by a single drift over the whole fishable area of the various banks (Table XI) the "total available fish potential" of the Mauritius-Seychelles Arch was calculated by Wheeler (in Wheeler and Ommanney 1953) as 1, 114, 249 tons of fish and 825, 145 tons of shark, exclusive of the value of areas at Mauritius, St. Brandon and the Seychelles worked by local fishermen

Taking the yearly catch of 10 tons per square mile as a constant, based on calculations of the inshore fisheries of Mauritius, Wheeler speculatively calculated that "the Mauritius - Seychelles Arc should be capable of yielding 9, 805, 396 tons in the first year and 2, 774, 200 tons annually thereafter". He further suggested that in view of the fact that the catches on the banks consisted of mature fish of greater weight than those taken in Mauritius, and that the selective action of line fishing combined with the use of large hooks protects the majority of the younger-up-to-maturity, securing therefore the stock and maintenance of an optimum catch, in spite of intensive exploitation by line fishing the minimum catch would be higher than the Mauritius inshore fishery.

Pelagic fish

Ommanney (in Wheeler and Ommanney 1953) surveyed what he called (a) the true surface wanderers, (b) the species caught between surface and bottom, and (c) the shoaling plankton feeding fishes caught in inshore waters by local fishermen.

Of the waters surveyed, the most fruitful trolling grounds were the waters of the Seychelles Plateau and the Almirante Bank, the Aldabra group and the Providence and Farquhar Islands during the months of the NW monsoon (mid-November to mid-April).

The pelagic fishes were found to be restricted to waters within the 100 fathom line over the banks and close inshore around islands.

Bonito (Euthynnus affinis affinis), dorado (Coryphaena hippurus) were the commonest of the pelagic species. The job (Aprion virescens) common throughout the whole area was more often taken by hand line than by trolling.

In Table XII by Ommanney, monthly catches of bottom and pelagic fishes are compared. Trolling was done with one or two lines with one hook each, bottom fishing with an average of five lines with three or four hooks each.

Ommanney calculated "the available fish potential" for the various islands and banks surveyed. He concluded that the quantity of fish available over the Seychelles Plateau - the richest ground - during the best months of the season (February, March and April) was approximately 2, 200 tons. This he considered a rough estimate because rate of recruitment and mortality were not known. The intensity of fishing was expressed as number of boats working eight lines for 12 hours a day.

The most abundant pelagic fishes of class (c) are the green striped mackerel (Rastrelliger kanagurta), the carangid (Caranx crumenopthalmus) and the blue mackerel (Caesio caerulaureus). The two first are taken by light seines and hand lines with several small hooks. The third, although abundant, cannot be taken by the same gear. Trials made with two types of drift net we

inconclusive. The general conclusion reached on trolling in Seychelles waters was that it could not be commercially profitable and could only be regarded as an adjunt to bottom fishing.

The Mozambique Channel and Madagascar waters

Gonçalves Sanches (1960) briefly described the fisheries of Mozambique and gave the following production and trade totals for 1954: total production 2,685; imports 4,254; exports 207 tons. The imports surpassed the local production by one-and-a-half times the local production. This author believed that by improving the present fishing methods, which consist mainly of coastal seining, handlines and trapping, and through research production could be doubled or trebled.

The fishery resources of Madagascar, particularly those of the west coast, are similar to the resources of the Mauritius-Seychelles Arch. A number of the species of Clupeiods, Scombriods, Coryphaenids, Lutianids, Lethrinids and Serranids of actual or potential value in that area are also important in Madascar as indicated by Petit (1930) (see Tables III, IV and V).

The SW African fish fauna has its distribution boundary in the Agulhas waters. The Agulhas Bank itself is relatively poor for trawling, although some grounds between the Cape of Good Hope and Durban are worked by a few trawlers. The principal species taken at present are: crabs in shallow water, and crayfish (Panulirus) in deep water, rock oysters, shrimp, mussels, mullets (in the river mouths)and most of the species listed in Tables III, IV and V, which are caught by lines.

8 THE TUNA RESOURCES OF THE INDIAN OCEAN

From the available information it seems that the most important potential fishery resource in the offshore waters of East Africa are the tuna stocks which are already being exploited and which will presumably continue to be the subject of increasing exploitation.

The distribution of the fishing grounds for albacore, according to Mimura (1957) is shown in Figure 11. The following conclusions on the distribution of tunas in the Indian Ocean are from Nakamura, Yabuta and Mimura (1956):

The principal species are: southern blufin (Thunnus thynnus macoyii), albacore (Germo germo), big-eyed tuna (Parathunnus mebachi), yellowfin (Neothunnus macropterus) and several species of marlins. Because of the taxonomic problems, it has not yet been determined whether they are the same species as those of the Pacific. Supposing, however, that they are, it seems doubtful that there could be much mixing of stocks between the two Oceans.

There are as yet insufficient data to explain the seasonal variations in the fishing conditions of tunas over the whole area of the Indian Ocean. The following preliminary conclusions are from Nakamura et al (1957):

> "The distribution of southern bluefin seems to be restricted to the area from the north and west coast of Australia to the adjacent seas of Sunda Strait; it is quite rare in the Indian Ocean proper. The hooked-rate (number of fish caught per 100 hooks) is at a mimimum between June and July, and reaches over 2% in September and February. The fishing ground extends to the west to 100°E longitude between January and March."

Albacore appears to be restricted to the Southern Equatorial waters and is especially abundant in waters south of 10°S. In some seasons the fish is distributed in the North Equatorial waters but the area of this distribution seems to be limited to the east at about 90°E. The best fishing season is between May and June, after which fishing activity declines gradually until October. Big-eyed tuna is distributed widely. Although the central area of distribution is not distinct, the density seems to decrease gradually to the west and it is rather rare in the seas south of 10°S. The best fishing season is between July and September and the change of fishing condition is two or three months later than that of the albacore. The distribution of yellowfin tuna is wider than that of the big-eyed tuna, and this fish seems to be rather abundant in the area 5° to 25°S where the best fishing season is between October and January with the maximum hooked-rate occuring in January. North of the Equator the fishing season appears to be between January and June.

Table I

CONTINENTAL SHELVES OF THE INDIAN OCEAN

Name of the Shelf	Area in $1000\ km^2$	Average depth (or depth range) m	Remarks (Nature of the bottom, etc)
1 Agulhas	110	100 (50 - 150)	Little productive. Very few good harbours. Rocky coast. Irregular and bad bottom.
2. Madagascar	180	15	Little productive. Very coralline and rocky. No good harbours.
3. Island shelves in central Indian Ocean	240	40 - 80	Medium productive. Most of the shelves are coralline
4. Zambesi	60	30	Little productive. Generally rocky, except off Zambesi river.
5. Persian Gulf	240	35	NW part has good bottom and is medium productive; SE part is rocky and very shallow; N part rocky and deeper with rocky coast.
6. Bombay	300	NE 20 Rest 80	NE part is shallow (ca 20 m) has good trawling grounds and is productive. S part is rocky and medium productive with exception of Wadje Banks which have good trawling ground and are productive.
7. Bengal-Burma			
7.1 Bengal	17O	N 15 Rest 50 - 100	N shallow part is medium productive. Rest is low productive.
7.2 Burma	380	(80)	Little productive. Rocky coast with numerous offshore islands. Coralline.
8. Arafura	1,350	(70)	Little productive. Rocky and coralline. No good shelters along the coast.

Table I (continued)

Name of the Shelf	Area in 1000 km^2	Average depth (or depth range) m	Remarks (Nature of the bottom, etc.)
9. NW Australian	300	80	Little to medium productive. Irregular groupy bottom. NE coast has many offshore islands. Rest of coast offers little shelter.
10 S. Australian	300	40 - 130	Medium productive. Only central part has some good shelters.

References to Table I in text on page: 2.

Notes to Table II

Air and water temperatures

1) First number refers to average of coldest month; second number to that of warmest month.

2) Air temperatures are rounded off to closest 2.5°C and water temperatures to closest full °C.

Winds and currents

3) Abbreviations for seasons:

Wi - Northern winter (usually average for month of February);

Su - Northern summer (usually average for month of August);

At - Northern autumn;

Sp - Northern spring;

4) Resultant force of wind and average speed of currents: First value refers to northern winter; second to northern summer.

5) Frequency of gales and storms:

\- Almost absent or rare;

\+ Moderately frequent;

++ Frequent;

+++ Very frequent.

6) Use of parentheses: the values in parentheses do not represent average of the area.

Notes to Table II

Air and water temperatures

1) First number refers to average of coldest month; second number to that of warmest month.

2) Air temperatures are rounded off to closest 2.5°C and water temperatures to closest full °C.

Winds and currents

3) Abbreviations for seasons:

Wi - Northern winter (usually average for month of February);

Su - Northern summer (usually average for month of August);

At - Northern autumn;

Sp - Northern spring;

4) Resultant force of wind and average speed of currents: First value refers to northern winter; second to northern summer.

5) Frequency of gales and storms:

\- Almost absent or rare;

\+ Moderately frequent;

++ Frequent;

+++ Very frequent.

6) Use of parentheses: the values in parentheses do not represent average of the area.

Table III

BIOLOGICAL AND FISHERY REGISTER - PELAGIC SPECIES OF FISH - EAST AFRICA

Species	Fish size (cm) l	Fish size (cm) s	Fish weight (lbs) l	Fish weight (lbs) s	Economic Value	Abundance	Maturity Age Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal Abundance
SPHYRAENIDAE											
											Y (K. T.)
Sphyraena commersoni	152	65	36	3	+	A		9-5 (?)		T	Y
S. genie	119		14							T	
S. japonica [3]					+	A					
S. jello	127	45	19	1	+			9-5 (A)		T, HL	Y
S. obtusata					+	A					
BELONIDAE											
Tylosurus crocodilus					+	A				T, H, FL	Y
T. leirus					+	A				T, H, FL	Y
SERRANIDAE [1]								12-3 (KT)			Y (KT) 12-3 [2] (KT)
Epinephelus flavocaeruleus					+	A				BL, T, HL	Y
E. tauvina	152	38	105	2	+	A			Coral reefs & banks	T, SL	Y
Plectropoma maculatum	101	61	36	7	++	R		12-3 (?)	Offshore reefs	T, etc.	Y 12-3 [2] (KT)
Variola lauti	78	28	8	0.5		R					Y
CARANGIDAE [1]								12-3 (KT)			Y (KT) 12-3 [2] (KT)
Caranx (Carangoides) fulvoguttatus	101	61	19	5	-	R		8-11 (?)	Shallow waters	T, HL	
C. (Cara.) gymnostethoides	88	67	20	9	-	R			Shallow waters	T, HL	

Table III (continued)

Species	Fish size (cm) l	s	Fish weight (lbs) l	s	Economic Value	Abundance	Maturity Age Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal abundance
C. (Caranx) ignobilis	122.5	40	42	2.25	+++	A		11-3		T	12-3 7-9
C. (C.) melampygus	80	53	17	3	+	A		12-3(KT)	Coral reefs	T etc.	12-3
C. (C.) sansum	83	57	13	6	-	A				T etc.	Y
C. (C.) sexfasciatus elacata	77.5	35.5	8	1	+	R				BS, T, HL	Y
Chorinemus lysan	105	90	16	13		R		9-3 (KT)		T, etc.	12-3
Elagatis bipinnulatus	94	56	10	2.5		R		12-3 (KT)		T	12-3
Megalaspis cordyla					-	R				T	Y
Selar crumenophthalmus					++(S)	A					9-5 (S)
Seriola dumerili					+ (S)	A(S)					9-5 (S)
CORYPHAENIDAE											
Coryphaena hippurus	140	64	15	2.5	+	AA		1-6 (KT)	Surface waters	F, FL	4-5[2/] 9-5 (S) 1-6 (Z) (KT)
LUTIANIDAE								12-3 (KT)			Y (KT) 12-3 (KT)
Aprion virescens	100	51	24	2	++	A		12-3		T, HL	Y 12-3[2/] (KT)
Lutianus bohar					-	A				T, etc.	
L. rivulatus					-	R				T, etc.	
THUNNIDAE											
Euthynnus affinis affinis	84	44	16	2	++	AA			Surface	T, etc.	9-5 (S) 12-3[2/] (KT) Y

Table III (continued)

Species	Fish size (cm) l	Fish size (cm) s	Fish weight (lbs) l	Fish weight (lbs) s	Economic Value	Abundance	Maturity Age	Maturity Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal Abundance
Euthynnus (Katsuwonus) pelamis						A						Y 12-3[2/] (KT) 9-5 (S)
Thunnus (Neothunnus) albacora	131	64	63	6.5	++	A				Sub-surface		9-5 (S) Y 12-3[2/] (KT)
Thunnus (Kishinoella) tonggol					++(S)	A(S)						9-5 (S)
CYBIIDAE												Y
Acanthocybium solandri	154	108	55	15	-	A				Surface		6-10
Gymnosarda nuda					-	R						Y 12-3[2/] (KT)
SCOMBRIDAE												Y
Auxis thazard						R(S)						9-5 (S)
Sarda orientalis						R(S)						9-5 (S)
Scombreromorus commerson	129	72	41	4	++	A			11-5(?)		T etc.	11-2/3-7[2/] 2-5 (S)
CLUPEIDAE												
Sardinella longiceps					++(S)	A(S)						9-5 (S)

Refs: pp. 5, 9.

Notes to Table III

A	Abundant
AA	Most abundant
R	Rare
Y	Throughout the year
T	Troll
HL	Hand line
FL	Floating baited lines
TN	Trammel net
BL	Bottom line
Tr	Traps
IS	Inshore
H	Harpoon
FL	Floating line
SL	Set line
BS	Beach seine

l	largest
s	smallest

S	Somalia
Se	Seychelles
K	Kenya
T	Tanganyika
Z	Zanzibar

1/ More numerous during 12-3 (NE monsoon)

2/ Months of greatest abundance

3/ Union of South Africa, Mozambique

Table IV

BIOLOGICAL AND FISHERY REGISTER - PELAGIC SPECIES OF FISH - MAURITIUS - SEYCHELLES

Species	Fish size (cm) l	Fish size (cm) s	Fish weight (lbs) l	Fish weight (lbs) s	Economic Value	Abundance	Maturity Age	Maturity Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal abundance
CORYPHAENIDAE						A						2-4 2/
Coryphaena hippurus	138	107	26	-	+	A		85-95			T, HL	9-4 (M, S)
THUNNIDAE						A						2-4 2/
Euthynnus affinis affinis	87	82	19	-	++	A	3(?)	50-85	9/10-3/4		T HL	9-4 (M, S)
Thunnus (Neothunnus) albacora	106	84	28	16	++	A				Offshore, surface	T, HL	2 7 (?)
CYBIIDAE												
Gymnosarda nuda	115	78	38	12		A				Inshore	T HL	4 10 (S)
Acanthocybium solandri	141	111	30	17	-	R				Offshore	T	
SPHYRAENIDAE												
Sphyraena commersoni	141	83	30	5	++	A			5 (?)	Inshore	T, HL	4-5/11-12
S jello					++(S)	A					HL	3
S. obtusata						R						
CARANGIDAE												
Elagatis bipinnulatus											T, HL	
Caranx (Carangoides) fulvoguttatus	112	47	25	2.5	++	A	5♀ 4-5♂	80♀ 85♂	11-4	Offshore	T, HL	Y 1-2 2/
C. (Carangoides) gymnostethoides	99	51	24	4	+++	A				Inshore	T, HL	3-5 2/ (S) 9/10-3/5(S)

Table IV (continued)

Species	Fish size (cm) l	Fish size (cm) s	Fish weight (lbs) l	Fish weight (lbs) s	Economic Value	Abundance	Maturity Age	Maturity Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal abundance
Caranx (Caranx) melampygus					+	A				Inshore		9-3(?)(S)
C. (C.) sexfasciatus	117	59	45	6	++	A		90♀ 75-95♂		Inshore	T, HL	
elacate												
C. crumenopthalmus					++	A					Seine, H.L.	11/12-4(M) 12-4[2/], Y(S)
ALBULIDAE												
Albula vulpes					+	A						9-3(?)(S)
SCOMBRIDAE												
Auxis thazard					+	A						
Rastrelliger canagurta					++	A				Inshore, Sandy-shallows	Seine, H.L.	11/12-4 (M) 12-4[2/], Y(S)
CAESIODIDAE												
Caesio coerulaureus												
LUTIANIDAE												
Aprion virescens	105	46	20	1.5	+++	A	3-4	70	9/10-3/4		T, HL	Y 12-2[2/]
Lutianus bohar					+++	A					BL, HL	
L. rivulatus					++	A					BL	
CARCHARHINIDAE												
Carcharinus amblyrhynchos					+	A						
C. albimarginatus					++	A						

Refs: pp. 5, 9.

Table V

BIOLOGICAL AND FISHERY REGISTER - DEMERSAL SPECIES OF FISH EAST AFRICA

Species	Fish size (cm)	Fish weight (lbs)	Economic Value	Abundance	Maturity Age Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal abundance
LUTIANIDAE									
Lutianus civis			+++	A					
L. fulviflamma									
L. gibbus								TN	
L. kasmira			+	A				TN	
L. marginatus									
L. russelli									
L. sanguineus			++	A				TN, BL	
L. sebae								BL	
L. vaigiensis									
LETHRINIDAE									
Lethrinus bungus									
L. caeruleus									
L. chaerorhynchus								TN	
L. croceopterus								TN	
L. harak			-	R					
L. kallopterus			++	A					
L. latifrons			++	A					
L. mahsena			-	R				TN	
L. mahsenoides			+	A				BL	

Table V (continued)

Species	Fish size (cm)	Fish weight (lbs)	Economic Value	Abundance	Maturity Age Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal Abundance
Lethrinus microdon								T, TN, BL	
L. miniatus			++	A				BL	
L. nebulosus			++	A				Tr, BL, HL	
L. oculatus			+++	A				BS, HL, Tr	
L. ramak			+++	A					
L. rostratus			+++	A					
L. waigensis			++	A				BL	
SERRANIDAE									
Cephalopholis argus			+	A					
C. aurantius			+	A					
C. miniatus			+	A					
C. rogaa			+	A					
Epinephelus areolatus			+					BL	
E. aurantius									
E. chlorostigma									
E. fasciatus			++	A					
E. flavocaeruleus			+	A				BL	
E. fluscoguttatus			+	A					
E. grammatophorus			+						
E. maculatus									
E. merra									

Table V (continued)

Species	Fish size (cm)	Fish weight (lbs)	Economic Value	Abundance	Maturity Age	Maturity Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal abundance
Epinephelus miniatus										
E. summana										
E. tauvina			+	A						
Variola louti			++	A				Coral reefs & banks		Y
SPARIDAE										
Chrysoblephus puniceus			+++	A						
Petrus rupestris			+	A						
Polysteganus nufar			++	A						
P. praeorbitalis			+	A					BL	
P. undulosus			+	R						
Pterogymnus laniarius			+	A						
Rhabdosargus tricuspidens			++	A						
MULLIDAE										
Parupeneus spp.			++	A					HL, BS	
GADIDAE										
Merluccius capensis			+++	A(?)						
SCIAENIDAE										
Johnius hololepidotus			+++	A						

TN - Trammel net
BL - Bottom line
Tr - Traps
HL Hand line
BS Beach seine
Y Throughout the year

Refs: pp. 5, 9.

Table V (continued)

Species	Fish size (cm)	Fish weight (lbs)	Economic Value	Abundance	Maturity Age Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal Abundance
Lethrinus microdon								T, TN, BL	
L. miniatus			++	A				BL	
L. nebulosus			++	A				Tr, BL, HL	
L. oculatus			+++	A				BS, HL, Tr	
L. ramak			+++	A					
L. rostratus			+++	A					
L. waigensis			++	A				BL	
SERRANIDAE									
Cephalopholis argus			+	A					
C. aurantius			+	A					
C. miniatus			+	A					
C. rogaa			+	A					
Epinephelus areolatus			+					BL	
E. aurantius									
E. chlorostigma									
E. fasciatus			++	A					
E. flavocaeruleus			+	A				BL	
E. fluscoguttatus			+	A					
E. grammatophorus			+						
E. maculatus									
E. merra									

Table V (continued)

Species	Fish size (cm)	Fish weight (lbs)	Economic Value	Abundance	Maturity Age	Maturity Size	Spawning season (month)	Fishing grounds	Fishing gear	Seasonal abundance
Epinephelus miniatus										
E. summana										
E. tauvina			+	A						
Variola louti			++	A				Coral reefs & banks		Y
SPARIDAE										
Chrysoblephus puniceus			+++	A						
Petrus rupestris			+	A						
Polysteganus nufar			++	A						
P. praeorbitalis			+	A					BL	
P. undulosus			+	R						
Pterogymnus laniarius			+	A						
Rhabdosargus tricuspidens			++	A						
MULLIDAE										
Parupeneus spp.			++	A					HL, BS	
GADIDAE										
Merluccius capensis			+++	A(?)						
SCIAENIDAE										
Johnius hololepidotus			+++	A						

TN - Trammel net
BL - Bottom line
Tr - Traps
HL Hand line
BS Beach seine
Y - Throughout the year

Refs: pp. 5, 9.

Table VI

CATCH AND LANDINGS OF MARINE FISHES IN EAST AFRICA[3/]
(FAO Yearbook of Fishery Statistics, Vol. VII, 1957)

Country		1953	1954	1955	1956	1957	1958	1959
				(Thousand metric tons)				
Kenya	CL			36.8	30 1	32.6	25.4	22.4
Madagascar	CL		2.6					
Mauritius[1/]	CL		1.6	1.6	1.7	1.7	1.6	1.3
Mozambique	CL		3.8	3.7	3.3	3.3	3.5	
Réunion	C		1.2	1.6	1.5	1.8	1.7	
	L		O.5	0.7	0.7	0.9	0.8	0.4
Seychelles[2/]	CL		1.5	1.5	1.5			
Somalia (Ital. Adm)	CL		7.4	5.3	9.5	17.1		
Tanganyika	CL		50.0	50.0	52.4	55.0	55.0	55.0
Zanzibar and Pemba	CL		8.8	8.7	8.8	8.8	8.8	8.8

L Landings (landed weight)
CL Catch and landings identical

1/ Includes Rodrigues and other dependencies
2/ FAO estimate
3/ Separate statistics for the east coast of Union of South Africa are not available.

Ref. p. 5

Table VII

ANALYSIS OF TUNA-CLIPPER CATCH BY SPECIES
(FAO/ETAP Report no. 288)

Species	No. of days fishing	No. of fish	Total wt. (kg)	Average weight (kg)	No. of hours fishing	No. of fish per hour	Wt. per hour (kg)
Euthynnus affinis affinis	42	2,209	6,717	3.04	359	6.15	18.98
Thunnus (Kishinoella) tonggol	12	102	645	6.32	98	1.04	6.58
T. (Neothunnus) albacora	11	38	346	9.09	101	.37	3.33
Sarda orientalis	5	46	130	2.82	48	.96	2.7
Euthynnus (Katsuwonus) pelamis	2	50	135	2.7	19	2.63	7.1
Auxis thazard	1	3	6	2.0	12	.25	5
Scomberomorus commerson	31	250	3,248	12.99	260	.96	12.49
Carangids	23	120	1,069	8.9	171	.7	6.25
Scomberoids spp.	14	79	306	3.87	107	.73	2.85
Coryphaena hippurus	19	106	478	4.5	153	.69	3.12
Sphyraena spp.	5	16	53	3.31	38	.42	1.39
Sharks	5	18	3,690	205.0	56	.32	65.89

Ref. p.6

Table VIII

PERCENTAGES BY FAMILIES OF TOTAL WEIGHT OF FISH IN LBS

Families	Percentage
Carangidae (mainly C. ignobilis)	42.5
Scombridae (mainly S. commerson)	22.0
Sphyraenidae	12.0
Lutianidae (mainly Aprion virescens)	11.0
Serranidae	8.2
Coryphaenidae (mainly Coryphaena hippurus)	4.2

Table IX

LIST OF SECTIONS IN ORDER OF CATCH RATE

Section	Average catch rate lbs/line/hr
Zanzibar (Latham Is. only)	2.66
Mafia	1.82
Malindi 1/	1.75
Kilwa	1.56
Pemba	0.62
Lamu	0.61
Zanzibar (excluding Latham Is.)	0.47
Luidi	0.38
Mombassa	0.06

1/ High due to catch of August 1952.

Table X

MAURITIUS AND DEPENDENCIES

	Calculated fishable area sq. miles	Actual fishing time hrs	mins	Actual catches Fish lb.	Sharks lb	Rates in tons (avoir.) p.m.p.y Fish	Sharks
St. Brandon	900	11	45	787	636	8½	7
Mauritius	150	6	40	-	-	-	-
Rodrigues	350	2	30	41	11	2½	½
Chagos Archip	2,500	21	5	5,056	6,238	27½	33½
Totals	3,900	42	00	5,884	6,885	17	19½

OCEANIC BANKS

Hawkins bank	70	2	55	9	643	½	28
Soudan bank	240	15	15	917	576	8	5
Nazareth bank	3,100	18	55	2,959	1,161	22	9
Saya de Malha, coccyx	100	2	0	31	914	1½	52
Saya de Malha, corpus	4,450	22	20	4,603	3,130	26	18
Saya de Malha, cervix	700	13	50	4,785	6,807	40	55
Saya de Malha, caput	150	3	5	649	1,487	23	53
Fortune bank	126	8	55	323	5 180	4	62
Constant bank	200	14	50	1,011	4,428	8½	36½
Totals	9,136	102	5	15,287	24,326	19	30½

SEYCHELLES AND DEPENDENCIES

Seychelles plateau	3,000	94	50	10,798	12,925	13½	16
Aldabra Islands	17	17	25	2,841	-	18½	-
Amirante Islands	640	20	20	3,829	3,374	24	21
Platte Island and La Perle	100	4	45	587	1,283	13	29
Providence and Farquhar Is.	38	3	40	493	68	17	2½
Coetivy Island	100	-	35	51	9	11	2
Totals	3,895	141	30	18,599	17,659	16½	16

Ref. p.7

Table XI

EXPERIMENTAL CATCHES IN THE MAURITIUS - SEYCHELLES ARCH.

	Catch in cwts per 100 hours		
	Fish	Sharks	Total
Mauritius and Dependencies	117½	130	247½
Oceanic banks	120	220	340
Seychelles and Dependencies	112½	110	22½

Ref. p. 8

Table XII

THE MONTHLY CATCH OF BOTTOM FISHES AND PELAGIC FISHES
(Wheeler and Ommanney, 1953)

	Bottom fishes (not sharks)		Pelagic fishes		Percentage of total by trolling
	No.	Weight (lb)	No.	Weight (lb)	
1948					
January	114	862½	-	-	-
February	167	911¼	5	40	4.2
March	156	1,387½	17	178½	12.9
April	200	1,847½*	21	313½	17.0
May	213	1,058¾	3	55	4.9
June	317	1,055½	0	0	0
July	597	3,001½	6	130	4.1
August	47	190¼	0	0	0
September	59	613	1	8	1.3
October	910	7,377	4	31½	0.4
November	457	2,342½	2	33	1.4
December	30	603	11	159	20.9
Total	3,273	16,450	70	948½	5.8
1949					
January	258	1,816½	1	14	0.8
February	137	1,809½	2	22½	1.2
March	643	4,460½	59	428	9.6
April	119	1,474½	25	195	13.2
May	181	1,487½	1	6	0.4
June	9	85½	2	21	22.0
July	268	2,115	4	93	4.4
August	48	575	2	30	5.4
September	74	712½	18	293	41.1
October	-	-	-	-	-
November	268	1,829	19	248	13.5
December	593	5,026½	5	58	1.1
Total	2,578	15,403.¾	138	1,408½	9.1

* Not including weight of fishes taken in the lagoon at Cosmoledo and Aldabra.

Ref. p. 8

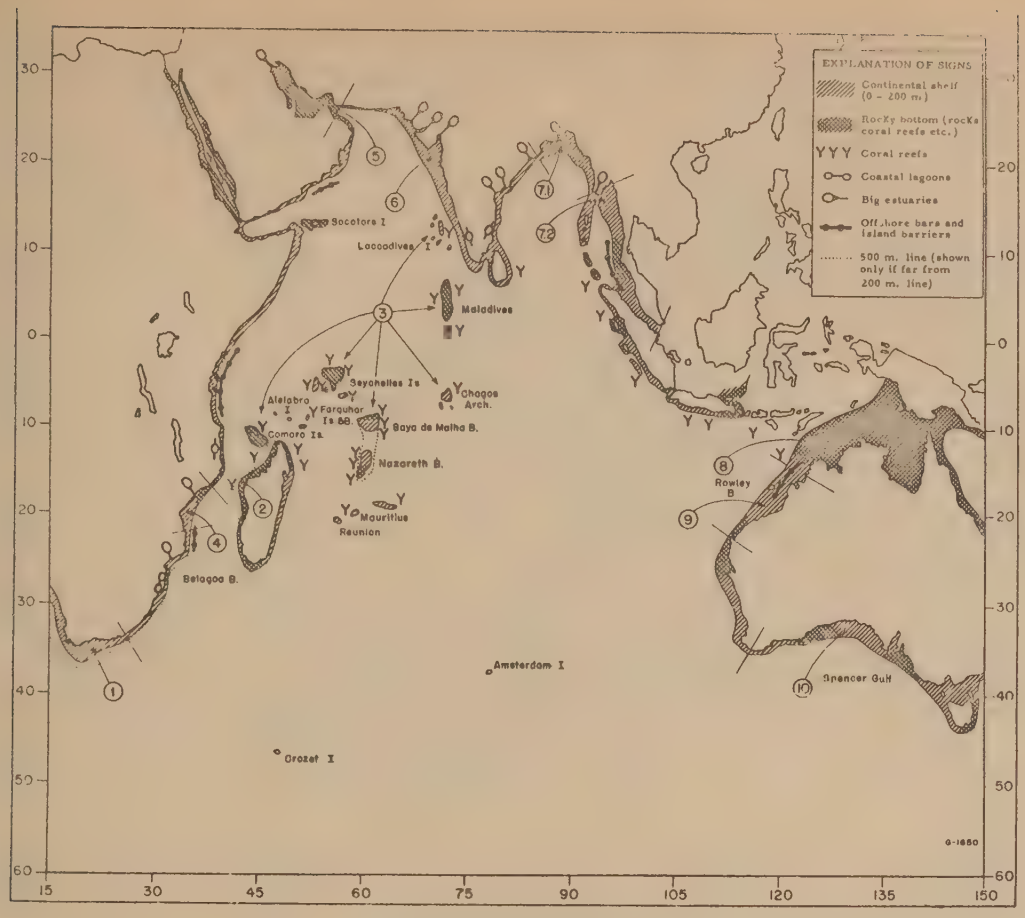

Fig. 1 CONTINENTAL SHELF OF THE INDIAN OCEAN

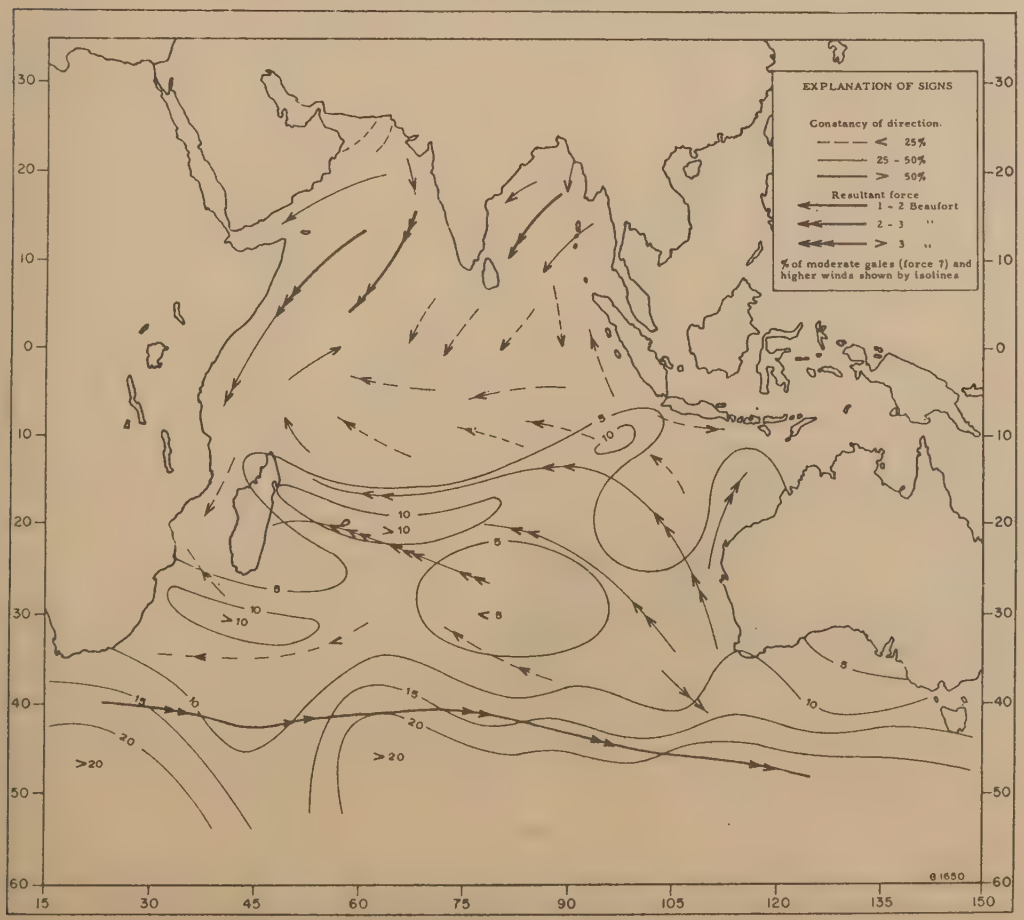

Fig. 2 RESULTANT DIRECTION AND FORCE OF WINDS AND PERCENTAGE OF MODERATE GALES (FORCE 7) AND HIGHER WINDS IN THE INDIAN OCEAN DURING FEBRUARY

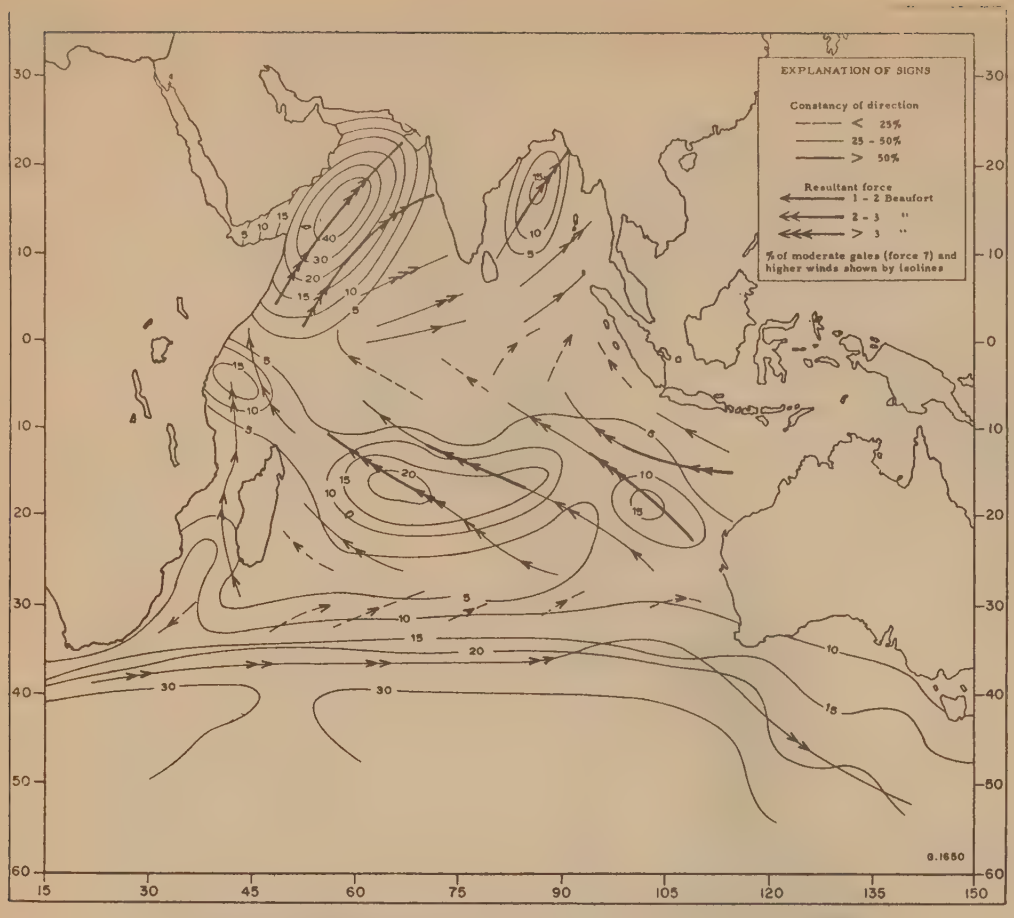

Fig. 3 RESULTANT DIRECTION AND FORCE OF WINDS AND PERCENTAGE OF MODERATE GALES (FORCE 7) AND HIGHER WINDS IN THE INDIAN OCEAN DURING JULY

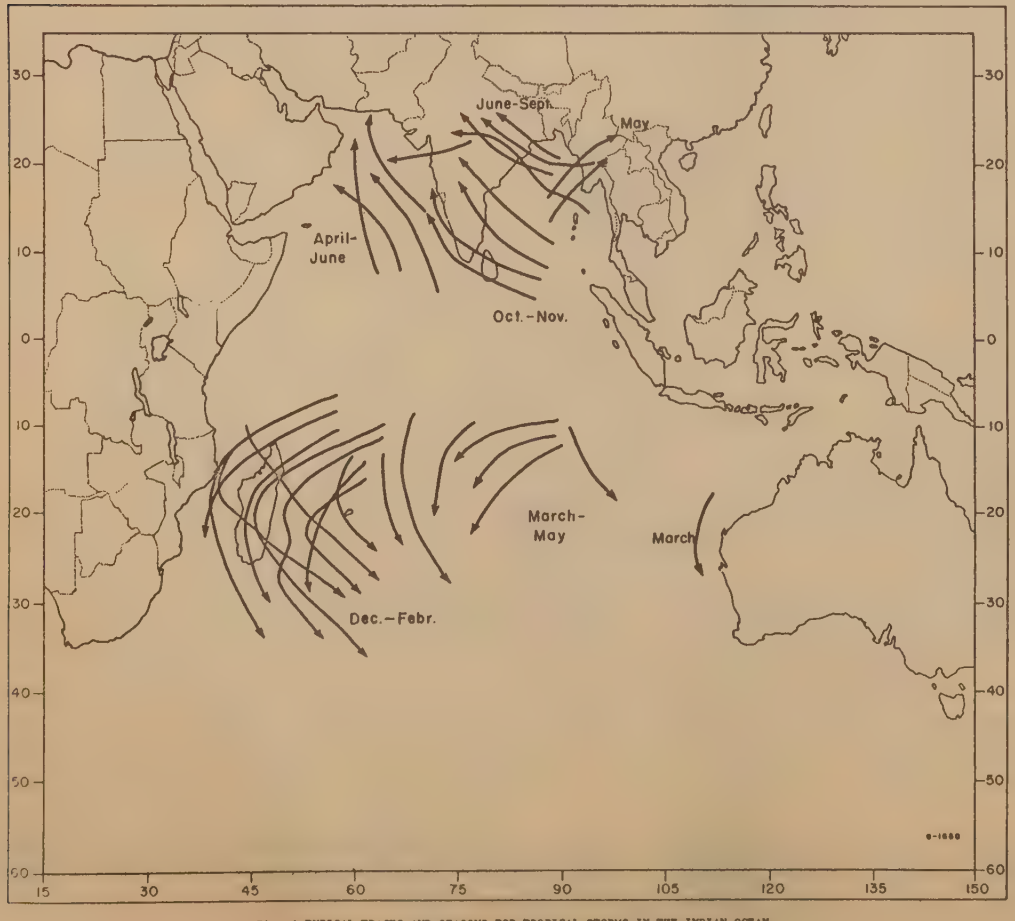

Fig. 4 TYPICAL TRACKS AND SEASONS FOR TROPICAL STORMS IN THE INDIAN OCEAN

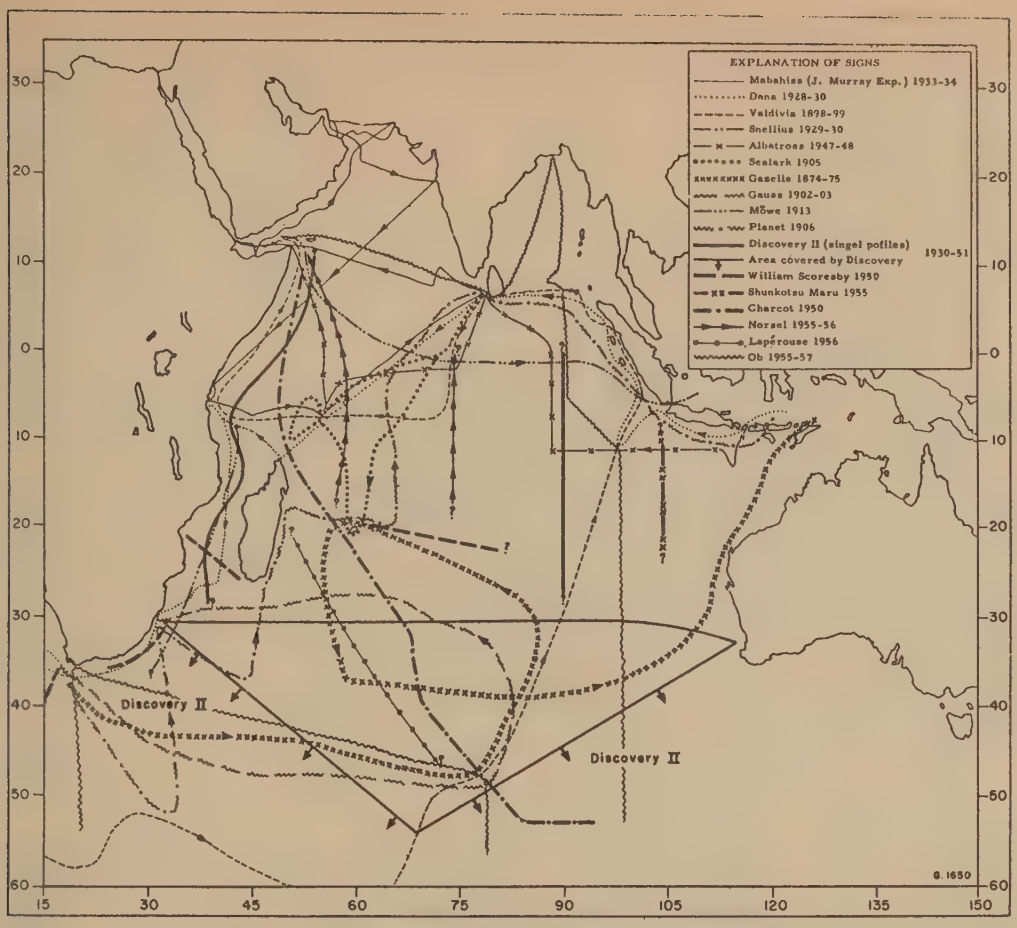

Fig. 5 ROUTES OF SOME EXPEDITIONS IN THE INDIAN OCEAN

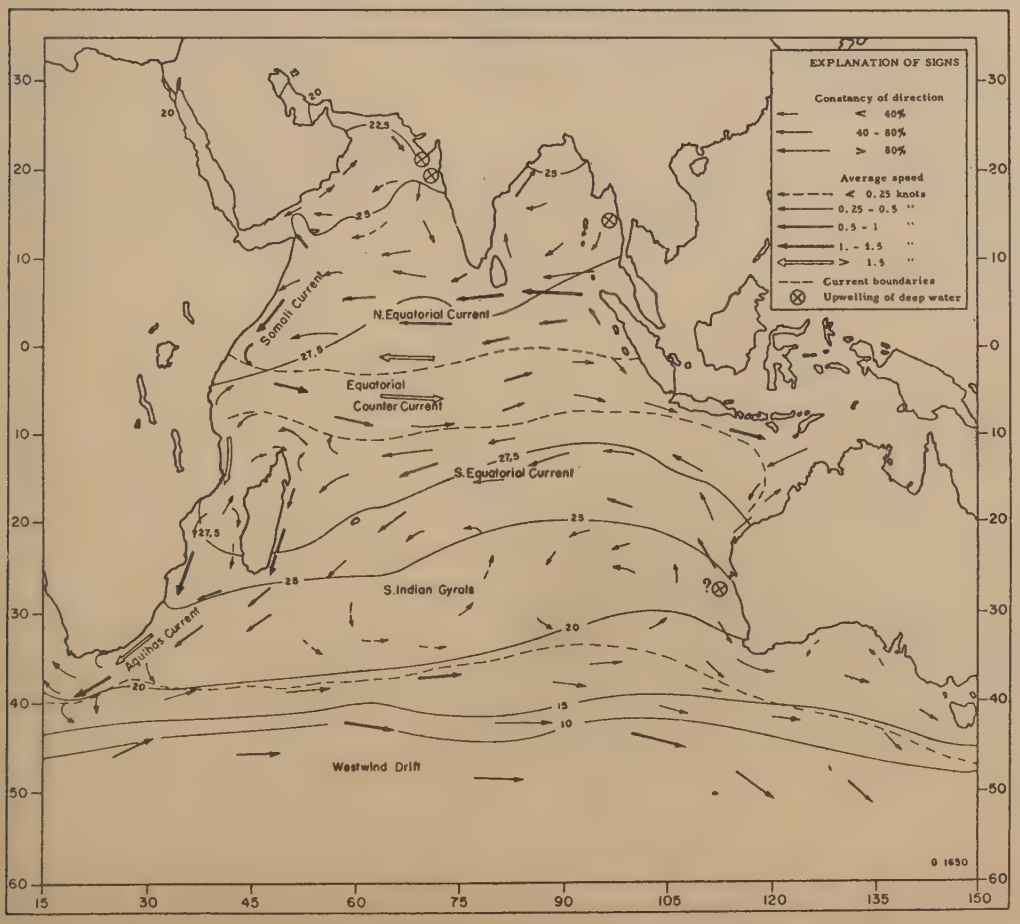

Fig. 6 SURFACE TEMPERATURE AND CURRENTS IN THE INDIAN OCEAN DURING FEBRUARY

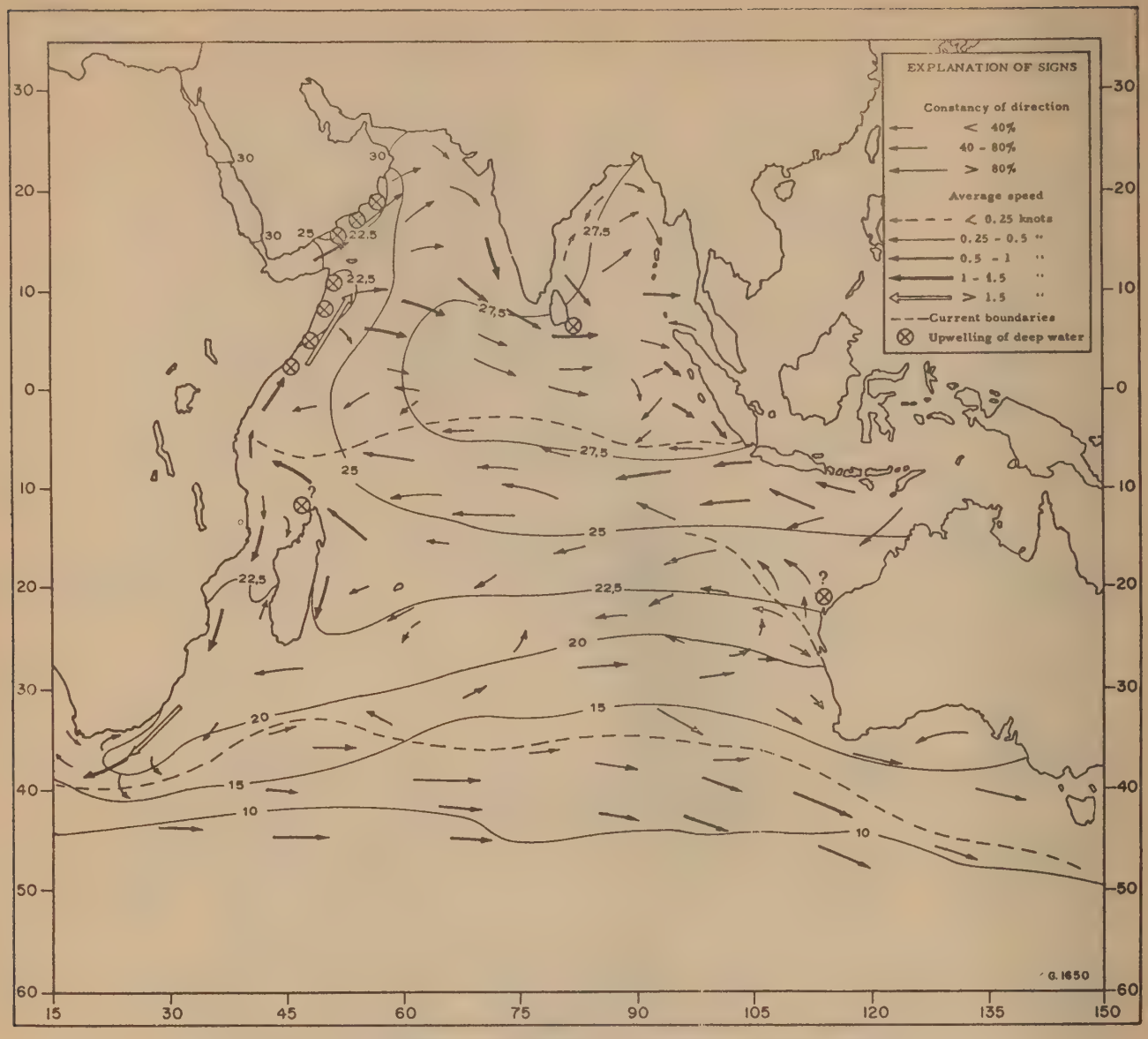

Fig. 7 SURFACE TEMPERATURE AND CURRENTS IN THE INDIAN OCEAN DURING AUGUST

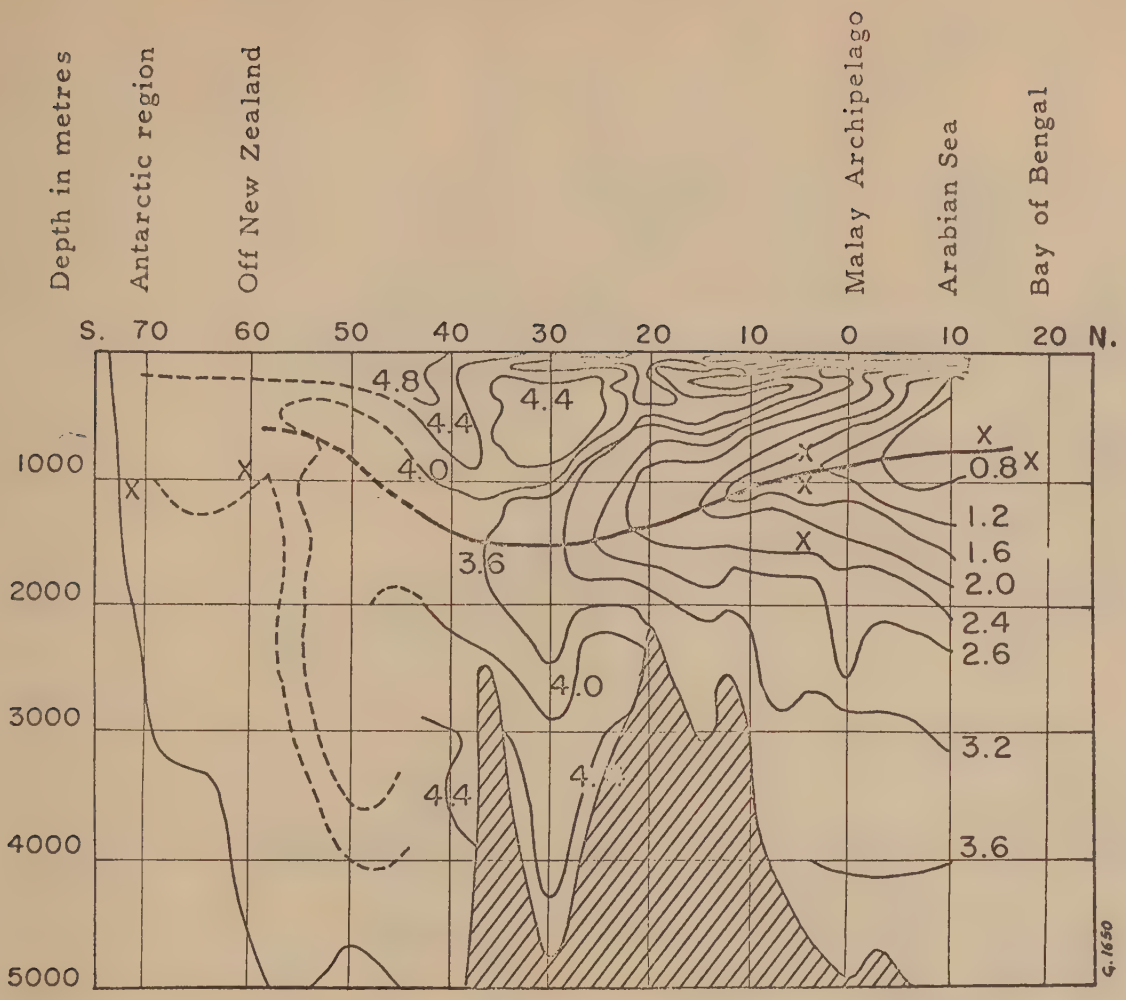

Fig. 8 Section of the Indian Ocean showing the O_2 concentration at different depths (after Clowes and Deacon, 1935)

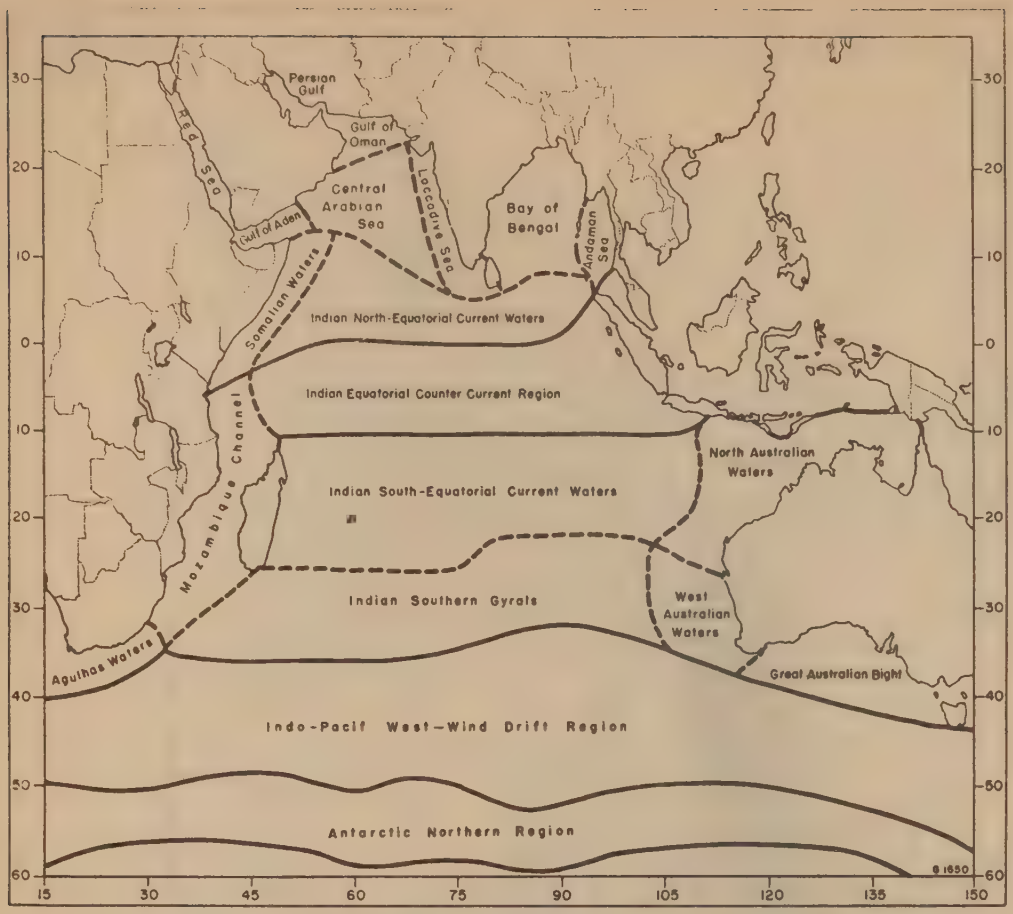

Fig. 9 NATURAL REGIONS OF THE INDIAN OCEAN

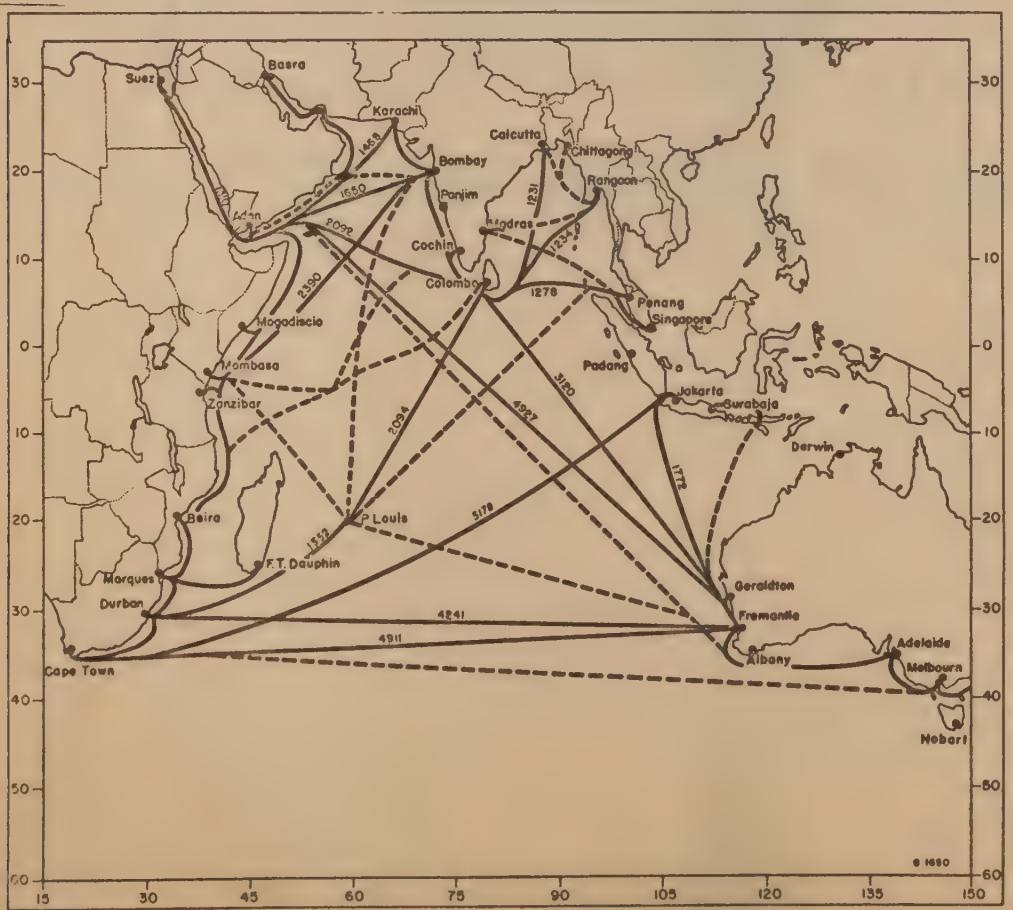

Fig. 10 SHIP ROUTES AND DISTANCES IN THE INDIAN OCEAN

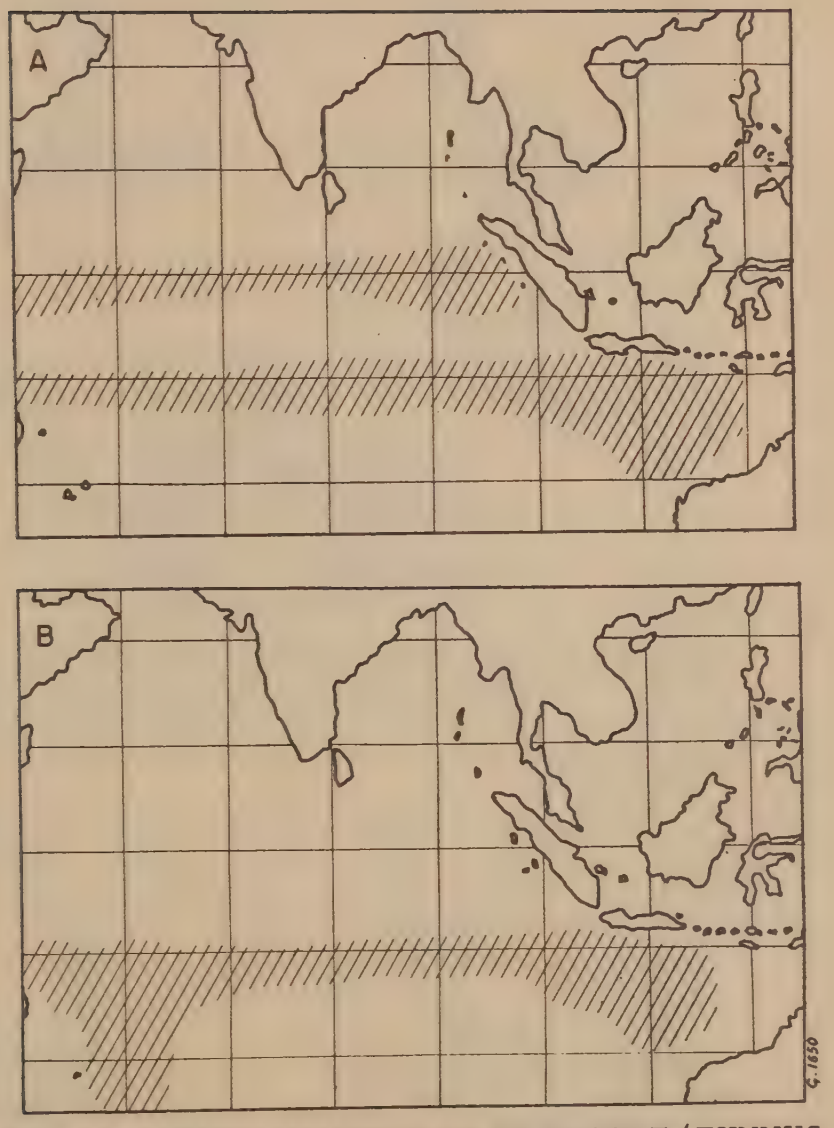

Fig. 11 FISHING GROUNDS OF ALBACORE (TUNNUS GERMO) IN THE INDIAN OCEAN
(after Mimura 1957)

A : JUL. - SEPT. B : JAN. - MAR.

Fig. 12 OCCURRENCE OF PELAGIC SPECIES-THUNNIFORMES AND SCOMBROIDEI

Fig. 13 OCCURRENCE PELAGIC SPECIES CLUPEIFORMES-CLUPEIDAE, ALEPOCEPHALIDAE, ENGRAULIDAE, ALBULIDAE

Fig. 14 OCCURRENCE OF PELAGIC AND SEMIPELAGIC SPECIES-CARANGIDAE, SPHYRAENIDAE, BELONIDAE, LUTIANIDAE, CAESIODIDAE, ALBULIDAE, SERRANIDAE

Fig. 15 OCCURRENCE OF LAMNIFORMES, SQUALIFORMES, RAJIFORMES

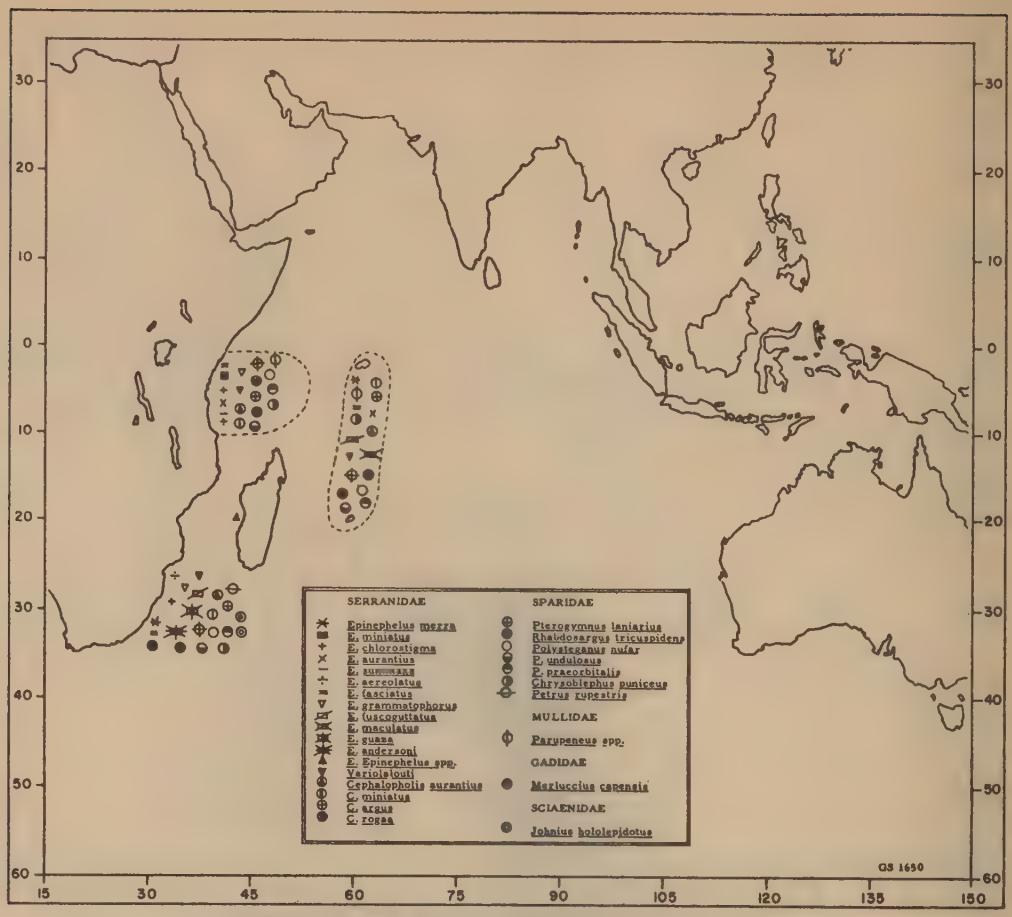

Fig. 16 OCCURRENCE OF DEMERSAL SPECIES-SERRANIDAE, SPARIDAE, MULLIDAE, GADIDAE, SCIAENIDAE

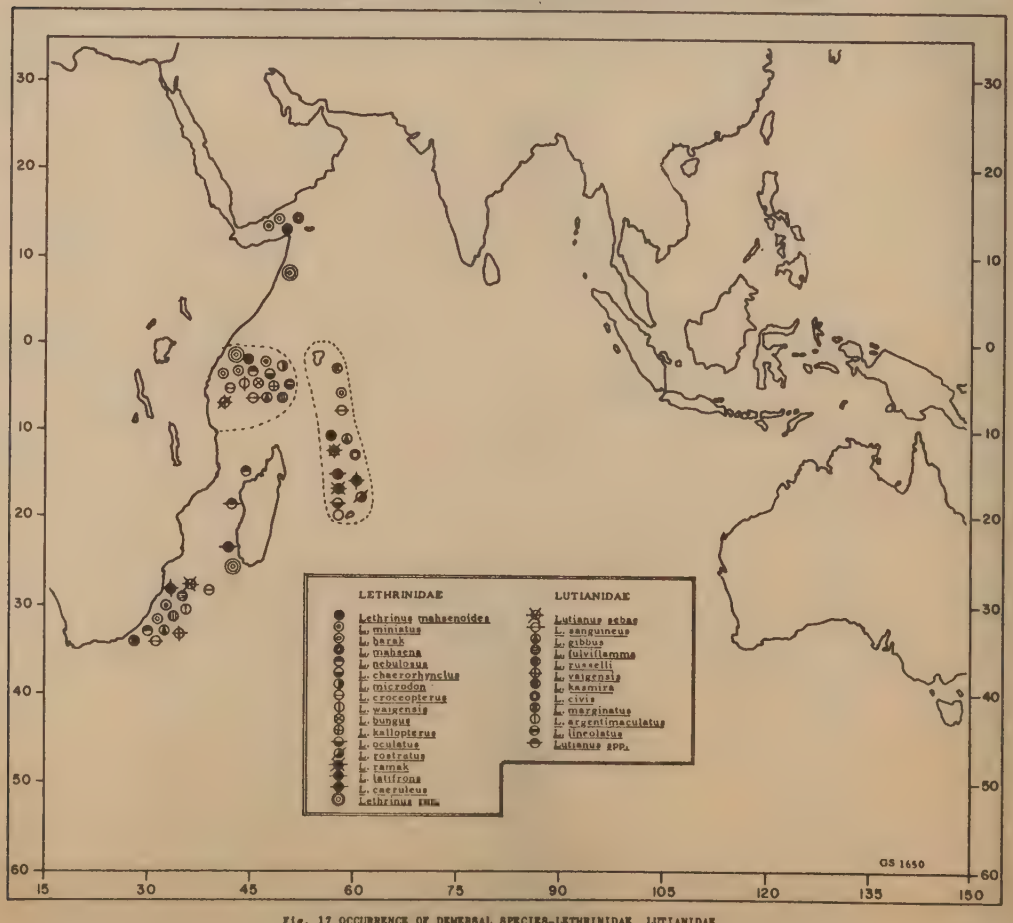

Fig. 17 OCCURRENCE OF DEMERSAL SPECIES-LETHRINIDAE, LUTIANIDAE

Appendix I to: Fisheries Resources of the East Coast of Africa and of the Central Indian Ocean, by H. Rosa and T. Laevastu, FAO Fisheries Biology Br.

Contribution to a bibliography on the oceanography and marine biology of the Indian Ocean

by

FAO, Fisheries Biology Br.

with the collaboration of

J. R. Lumby

Director, IGY, WDC-A,
Oceanography, Texas A and
M College

Contents

Explanatory notes

1. Atlases, charts
2. Summaries (General)
3. Expeditions and other data reports
4. Meteorology, interactions between the sea and the atmosphere
5. Physical oceanography (general)
6. Dynamics and circulation
7. Chemical oceanography (including nutrient salts)
8. Submarine geology, geochemistry
9. Plankton (general)
10. Phytoplankton
11. Zooplankton
12. Benthos
13. Productivity (general)
14. Nekton (including fisheries)

Explanatory notes

The present contribution to an Indian Ocean bibliography is somewhat selective, especially in the following respects:

1. Relatively few old references have been included. Additional old references (before 1935) can be found in the references given in Chapter 2, especially under G. Schott (1935).

2. Only a very few detailed references have been taken from the expedition reports given in Chapter 3. These reports contain much material relevant to Chapters 8 to 12 of this bibliography. As an example could be mentioned the "Valdivia" reports, published in 102 volumes, which contain taxonomic accounts and notes on the distribution of most plankton found in the Indian Ocean.

3. It is a characteristic of the literature on the Indian Ocean that a relatively large quantity of "rough" data is available, but there is a lack of summaries, analyses and quantitative considerations.

4. Professor T. H. Day, Director, Department of Zoology, University of Cape Town, Rondebosch, Cape Province, South Africa, tells us that he possesses an extensive biological bibliography on cards for the Indian Ocean. A biological bibliography on the Indian Ocean from 1957 to 1960, is in preparation in FAO Fisheries Biology Branch.

1. Atlases, charts

1. Bureau Hydrographique Internationale, Carte Générale Bathymétrique des Océans. Monaco.

2. Koninklijk Nederlands Meteorologisch Institut. Red Sea and Gulf of Aden. 1949

3. _____, Climatological Atlas of the Indian Ocean. 1952

4. _____, Indian Ocean Oceanographic and Meteorological Data. No. 135

5. Meteorological Office, London. Meteorological Charts of the Red Sea. 1895

6. _____, Indian Ocean Currents. MO 392. 1939

7. _____, Monthly Meteorological Charts of the Indian Ocean. 1952 MO 519

8. U.S. Navy Hydrographic Office. Monthly Surface Temperature Charts of the Indian Ocean. H.O.Misc.No. 10,619 1943

9. _____, World Atlas of Sea Surface Temperatures. H.O.Publ. No. 225 1944

10. _____, Atlas of Sea and Swell Charts - Indian Ocean. H.O.Publ. No. 799-G 1944

11. _____, Atlas of Surface Currents - Indian Ocean. H.O.Publ. No. 566 1950

12. _____, Atlas of Pilot Charts - South Pacific and Indian Oceans. H.O.Publ.No. 577 1955

13. U.S. Navy, Marine Climatic Atlas of the World, Vol. III, Indian Ocean 1957

14. U.S. Weather Bureau, Atlas of Climatic Charts of the Oceans. 1938

2. Summaries (general)

1. Dietrich, G. and K. Kalle, Allgemeine Meereskunde. Eine Einführung in die Ozeanographie. Gebr.Borntraeger, Berlin - Nikolassee 1957

2. Krishnaswami, S. The coasts of India. Indian geogr.J. 29(1):18-22
1954

3. Morgans, J.F.C., The North Kenya Banks. Nature,Lond., 184:259-60
1959

4. Nanda, J.N., Physical oceanography in India. Proc.UNESCO Symp.
1957 Phys.Oceanogr., Tokyo, pp.179-81

5. Quereshi, M.R., Oceanography in Pakistan. Proc.UNESCO Symp.Phys.
1957 Oceanogr.1955 Tokyo, pp. 207-13

6. Satyanarayana Rao, T.S., Science and the Indian Ocean. Sea Frontiers,
1957 3:143-7

7. Schott, G. Geographie des Indischen und Stillen Ozeans, Boysen,
1945 Hamburg, 413 pp.

8. Sverdrup, H.U., M.W. Johnson and R.H. Fleming, The Oceans, their
1942 physics, chemistry and general biology. Prentice-Hall,
N.Y. 1087 pp.

3. Expeditions and other data reports

1. Reise der Osterreichisches Korvette "Novara" um die Erde in den
1861- jahren 1857-1859, Hydrogr.Anstalt der K.K. Marine Wien.
1893

2. Expedition S.M. Schiff"Pola" im Mittelländischen Ägäischen und Rothen
Meer in den jahren 1890-1898. Wissenschaftliche Ergebnisse. Ber.Komm.Ozeanogr.Forsch., Wien.

3. The Carlsberg Foundation's Oceanographic Expedition around the world,
1928-1930 and previous "Dana" expeditions under the leadership of the late Professor Johannes Schmidt. /Publ./
C.A. Reitzels, Copenhagen; Oxford Univ.Press, London

4. Scientific Results of the Danish Deep-sea Expedition round the World,
1950-1952. Galathea Committee, Copenhagen.

5. Expedition antarctique française (1903-1905). Sciences naturelles:
documents scientifiques 6 vol.

6. Die Forschungsreise SMS "Gazelle". Reichs-Marine-Amt, Berlin, 5 vol.
1888-1890

7. Deutsche Tiefsee - Expedition auf dem Dampfer "Valdivia", 1898-1899.
1902- Wissenschaftliche Ergebuisse d. deutsch. T.S.E. auf dem
1940 Dampfer "Valdivia", 1898-1899. Gustav Fischer, Yena, 102 vol.

8. Deutsche Südpolar-Expedition, 1901-1903. /Publ./ W. de Gruyter and Co., Berlin, 20 vol. 1905-1931

9. Die forschungsreise S.M.S. "Planet", 1906-1907, Reichs-Marine-Amt., Berlin, 5 vol. 1909-

10. The Snellius-Expedition in the eastern part of the Netherlands East-Indies, 1929-1930, under the leadership of P. M. van Riel /Publ./ E. J. Brill, Leiden.

11. Reports of the Swedish Deep Sea Expedition 1947-1948 (Albatross). /Publ./ Elander, Göteborg. 1951-

12. Reports of the scientific results of the voyage of H.M.S."Challenger" during the years 1873-1876 under the command of Captain George S. Nares and the late Captain Frank Tourls Thompson, R.N. Edinburgh, H.M.S.O. Challenger Office, U.K. 1880-1895

13. Report on the Scientific results of the H.M.S. "Challenger" during the years 1873-1876, ca 50 vol. 1884-1895

14. Report of the Percy Sladen Trust Expedition to the Indian Ocean (Sealark) 1905. /Publ./ Linn.Soc.London.

15. The John Murray Expedition. Scientific Reports, (Mabahiss 1935-1954). /Publ./ British Museum (Natural Hist.) London.

16. Discovery Reports, Colonial Office,(U.K.), Discovery Committee. /Publ./ University Press, Cambridge.

17. Bogorov, V.G., K.R. Olevinski and V.S. Samojlenko, Report on the scientific work on board the ice-cutter F. Litke during the voyage from Sevastopol to Vladivostok. Byull.Gosud. Okeanogr.Inst., 2 1931

18. Brennecke, W., Ozeanographische Arbeiten S.M.S. Möwe im westlichen Indischen Ozean 1913. Ann.Hydrogr.Berl., 43(8): 1915

19. _____, Die ozeanographische arbeiten der Deutschen Antarktischen Expedition 1911-1912. A.d.Arch.Dt.Seewarte, Hamburg 1921

20. Hydro-Met. Publ. House, Leningrad /Publ./, Hydrological, hydrochemical, geological and biological studies R.S. 1955-1956

21. Kon.Nederl.Meteorol.Instituut, /Publ./, Ozeanografisch en meteorologisch waarnemingen in den Indischen Ozeans, Vol. 4 1924-1930

4. Meteorology, interactions between the sea and the atmosphere

1. Albrecht, F., 1951 Montskarten des Niederschlages und der Verdunstung und das Wasserhaushalt des Indischen und Stillen Ozeans. Ber.dtsch.Wetterdienstes U.S. Zone No. 29

2. _____, 1958 Untersuchungen über den Wärmeumsatz an der Meeresoberfläche und die Meeresströmungen im Indischen Ozean. (Research on the heat exchange at the sea surface and the currents in the Indian Ocean). Geofis.pur.appl., 39:194-215

3. Kon.Nederl.Meteorol.Instituut, /Publ./ 1924-1930 Oceanografisch en meteorologisch waarnemingen in den Indischen Ozeans.

4. Poornachandra, C. Rao, 1957 Meteorological factors affecting the salinity of surface sea water off Waltair. Indian J.Met.Geophys., 8(3):347

5. Physical oceanography (general)

1. Chiba, T. et al., 1957 Oceanographical and planktological studies of the tuna-fishing grounds in the middle part of the north Indian Ocean. J.Shimonoseki Coll.Fish., 6(3):7-29

2. Clowes, A.J., 1951 An introduction to the hydrology of South African Waters. Invest.Rep.Fish.Mar.biol.Surv.S.Afr., 12: 42 pp. and charts

3. Deacon, G.E.R., 1937 The hydrology of the Southern Ocean. Discovery Rep. 15:1-123

4. Ganapati, P.N. and V.S.R. Murty, 1954 Salinity and temperature variations of the surface water off the Visakhapatnam Coast. Andhra Univ.Mem.in Oceanography, Waltair, 1:125

5. Isaac, W.E., 1937 South African Coastal Waters in Relation to Ocean Currents. Geogr.Rev. 27(4):651-64

6. Jayaraman, R. and S.S. Gogate, 1957 Salinity and temperature variations in the surface waters of the Arabian Sea off the Bombay and Saurashtra coasts. Proc.Indian Acad.Sci., Sec.B, 45:151-64

7. La Fond, E.C., 1954 Environmental factors affecting the vertical temperature structure of the upper layers of the sea. Andhra Univ.Mem. in Oceanogr.Waltair, 1:94

8. _____, 1957 Sea water density at four stations on the east coast of India. Indian J.Met.Geophys., 8:213-7

9. La Fond, E.C., Seasonal cycle of the sea surface temperatures and
1958 salinities along the east coast of India. Andhra Univ. Mem.in Oceanogr.Waltair, 2:12

10. La Fond, E.C. and P.V. Bhavanarayana, On a thermal feature of bottom
1957 water during upwelling on the east coast of India. Indian J.Met.Geophys., 8:209-12

11. Lutgens, R., Oberflächentemperaturen im südlichen Indischen Ozean
1905 1901 bis 1903. Ann.Hydrogr.Berl., 33(11):

12. Marchand, J.M., Salinity investigations in the South African Seas.
1928 Fish.and Mar.Biolog.Survey, Rep.No. 6, Cape Town

13. Maritime Safety Board, Tokyo, Oceanographic conditions in the district
1955 of the Indian Ocean (1) Hydrogr.Bull., Tokyo, 49:186 et foll.

14. _____, Oceanographic conditions in the district of the Indian
1955 Ocean (2) (In Japanese). Hydrogr.Bull., Tokyo, 50:237 et foll.

15. Muromtsev, A.M., Plotnost' vody no poverkhnosti Indiiskogo okeana.
1958 (Water density on the surface of the Indian Ocean). C.R.Acad. Sci.U.R.S.S., 123:1014-7

16. Murty, C.B., Water masses of the western central Bay of Bengal during
1957 November. Curr.Sci., 26(3):80

17. _____, On the temperature and salinity structures of the Bay of
1958 Bengal. Curr.Sci., 27:249

18. Newell, B.S., Preliminary survey of the hydrography of the British East
1957 African coastal waters. Fish.Publ.,London, (9):21 pp.

19. _____, Hydrography of the British East African Coastal Waters,
1959 Part II, Fish.Publ., London, (12):

20. Pollak, M.J., Frequency distribution of potential temperatures and
1958 salinities in the Indian Ocean. Deep-Sea Res., 5(2):128-33

21. Poornachandra Rao, C., Water masses in the Bay of Bengal. Curr.Sci.,
1956 2:51-3

22. Prasad, R., Preliminary observations of the temperature gradients and
1952 light penetration in the upper 200 feet of water in the Bay of Bengal. Proc.Indian Acad.Sci., 36:61-9

23. _____, Seasonal variation in the surface temperature of sea
1957 water at Mandapan from January 1950 to December 1954. Indian Jour.Fish., 4(1):20-31

24. Rochford, D.J., 1952 A comparison of the hydrological conditions off the eastern and western coasts of Australia. Indo-Pacific Fish.Couns.Proc.3rd Meeting 61-8

25. Rochford, D.J. and R.S. Spencer, 1957 Onshore and hydrographic investigations in eastern and southwestern Australia, 1956. Oceanographic Station Lists, 30:79

26. Satyanarayana, Rao, T.S., 1957 Studies on the penetration of light in the Bay of Bengal. Part I. Transparency of the waters on the East Coast of India and its significance. Proc.Nat.Inst. Sci., India, 23b:165-81

27. Schott, G., 1908 Der Salzgehalt des Persischen Golfes und der angrenzen den Gewässer. Ann.Hydrogr.Berl., 36(7):296-9

28. Sewell, R.B.S., 1938 Geographic and Oceanographic research in the Indian Ocean, No. 4: Temperature and salinity of the surface waters of the Bay of Bengal and Andaman Sea, No. 5: Temperature and salinity of the deep waters. Mem.Asiat.Soc.Beng. 9

29. Skibko, N.E., 1957 (Characteristics of the regime of winds and waves in the Red Sea, Indian Ocean and the south and east China Seas) Ru Trud.morsk.gidrofiz.Inst., 10:32-52

30. Tchernia, P., 1951 La structure hydrographique de l'ocean Indien. Bull.Com. centr.Océanogr., 3(10):422

31. Tchernia, p., H. Lacombe and P. Guibout, 1958 Sur quelques novelles observations hydrographiques relatives à la région équatoriale de l'ocean Indien. Bull.Com.centr.Océanogr., 10(3):115-143

32. Tchernia, P., J. LeFlock and H. Lacombe, 1951 Contribution à l'étude de l'Ocean Indien. Bull.Comm.centr.Océanogr. 3

33. Thompson, E.F., 1939 Chemical and physical investigations. The general hydrography of the Red Sea. Sci.Rep.Murray Exped., 1933-34, 2(3):

34. Tsuruta, A., et al, 1957 Oceanographical and planktological studies of tuna-fishing ground in the eastern part of the Indian Ocean. J.Shimonoseki Coll.Fish., 7(1):1-18

35. Wimpenny, R.S., 1930 Some hydrographic data from the Suez Canal, 1928-29. Coastg.Fish.Serv.,Bull.Fish.Res.Sect., Vol. 1 Cairo

36. Wüst, G., 1935 Fortschreitende Salzgehaltsabnahme im Suezkanal. Ann.Hydrogr. Berl., 63:391

6. Dynamics and circulation

1. Backhausen, F., Über Stromversetzung im Arabischen und Bengalischen Meer während des SW Monsuns. Der Seewart, (Hamburg), 15(5):27-30 — 1953

2. Balaramurty, C., and A.A. Ramasastry, Distribution of density and the associated currents at the sea surface in the Bay of Bengal. Indian J.Met.Geophys., 8:88-92 — 1957

3. Barlow, E.W., Surface currents in the Persian Gulf, North portion of the Arabian Sea and the Bay of Bengal. Mar.Obs., 8:193; 9:223, 11:19-21 — 1931, 1932, 1934

4. _____, Currents in the southern Indian Ocean, summer season and general summary. Mar.Obs., 10:132 — 1933

5. _____, Currents of the Red Sea and the part of the Indian Ocean north of Australia. Mar.Obs., 11:67-8; 111; 150-4. — 1934

6. _____, The 1910 to 1935 survey of the currents of the Indian Ocean and China Seas. Mar.Obs. 12(120): — 1935

7. Brodie, J.W. and R.W. Burling, Age determination of southern Ocean waters. Nature, Lond., 181:107-8 — 1958

8. Carruthers, J.N., S.S. Gogate, J.R. Naidu and T. Laevastu, Shoreward upslope of the layer of minimum oxygen off Bombay: its influence on marine biology, especially fisheries. Nature, Lond., 183:1084-7 — 1959

9. Clowes, A.J. and G.E.R. Deacon, The deep-water circulation of the Indian Ocean. Nature, Lond., (136):936-8 — 1935

10. Deacon, G.E.R., The hydrology of the Southern Ocean. Discovery Rep., 15:1-123 — 1937

11. Dietrich, G., Aufbau und Dynamik des Südlichen Agulhas-stromgebiets. Veröff.Inst.Meeresk., Univ.Berlin, Neue Folge, A,27:1-79 — 1935

12. Fairbairn, L.A., The semi-diurnal tides along the equator in the Indian Ocean. Phil.Trans.Roy.Soc.London (A), 247(927):191-212 — 1954

13. Gilchrist, J.D.F., Currents on the South African coast, as indicated by the course of drift bottles. Marine.Inves., South Africa, 2:155-65 — 1904

14. Jerlov, N.G., 1957 The equatorial currents of the Indian Ocean. Reports of the Swedish Deep-Sea Expedition, 1947-48, 3(5):115-25

15. Lacombs, H., 1951 Application de la méthode dynamique à la circulation dans l'ocean Indien et dans l'ocean Antarctique. Bull. Com.centr.Océanogr., 3(10):459

16. La Fond, E.C., 1954 On the circulation of the surface layers off the east coast of India. Assoc.Internat.Océanog.Phys.Proc.Verb., (Bergen), 6(254); Andhra Univ.Mem. in Oceanogr.Waltair, 2:1

17. La Fond, E.C. and C. Borreswara Rao, 1954 Rotary currents in the Bay of Bengal. Andhra Univ.Mem. in Oceanogr.Waltair, 1:102-8

18. La Fond, E.C. and R.C. Poornachandra, 1954 Vertical oscillations of tidal periods in the temperature structure of the sea. Andhra Univ.Mem.in Oceanogr.Waltair, 1:109-

19. Le Floch, J., 1951 Hydrologie et circulation de quelques masses d'eau de l'Ocean Indien. Bull.Com.centr.Océanogr., 3(10):433

20. Michaelis, G., 1923 Die Wasserbewegungen an der Oberflächen des Indischen Ozeans im Januar und Juli. Veröff.Inst.Meeresk.Univ.Berl. 16:

21. Möller, L., 1929 Die Zirkulation des Indischen Ozeans. Veröff.Inst.Meeresk. Univ.Berl., 21:1-48

22. _____, 1933 Zur Frage der Tiefenzirkulation im Indischen Ozean. Ann. Hydrog.Mar.Meteorol. 7(9):233-6

23. Newell, B.S., 1959 Hydrography of the British East African Coastal Waters, Part II. Fish.Publ.Lond. (12):

24. Paech, H., 1926 Die Oberflächenströmmungen im Madagaskar in ihrem jährlichen Gang. Veröff.Inst.Meeresk.Univ.Berl., 16:

25. Ramasastry, A.A. et al, 1957 Thermal field and oceanic circulation along the east coast of India. Proc.Indian Acad.Sci., 46:293-323

26. Schott, G., 1926 Die Tiefwasserbewegungen des Indischen Ozeans. Ann. Hydrog.Berl., 54(12):417-31

27. _____, 1929 Uber die Wasserbewegungen im Bab el Mandeb. Ann.Hydrogr., Berl., 57(1):10-14

28. Soeriaatmadja, Rd.E., 1957 The coastal current south of Java. Mar.Res. Indonesia, 3:41-55

29. Southwell, T. and J.C. Kerkham, Currents on the Ceylon Pearl Banks
1912 superficial and deep. Rep.Ceylon Mar.Biol.Lab. 1, 6(20)

30. Tchernia, P., La structure hydrographique de l'Ocean Indien. Bull.
1951 Com.centr.Océonogr., 3(10):422

31. _____, Sur l'origine des eaux salées profondes du nord-ouest de
1957 l'Ocean Indien. (On the origin of the deep salt waters in the north-west of the Indian Ocean) Bull.Com.centr.Océanogr., 9(10):545-50

32. Thompson, E.F., The general hydrography of the Red Sea. Exchange
1939 of water between the Red Sea and Gulf of Aden. Sci.Rep. John Murray Exp.

33. Thomsen, H., Entstehung und Verbreitung einiger charakteristischer
1935 Wassermassen in dem Indischen und Südlichen Pazifischen Ozean. Ann.Hydrog.Mar.Meteorol. 63:293-305

34. van Riel, P.M., De Stroomwegen van Ceylon naar de Golf van Adan in
1924 der Zuidwestmonson. Konink.Nederland Meteor.Inst., 102:

35. Willimzik, W., Die antarktischen Oberflächenströmungen zwischen
1924 50°O und 110°O. Veröff.Inst.Meeresk.Univ.Berl., 13(2):25-9

36. _____, Die Strömungen im Subtropischen Konvergenzgebeit des
1929 Indischen Ozeans. Veröff.Inst.Meeresk.Univ.Berl., A13(2):25-9

37. Wüst, G., Meridionale Schichtung und Tiefenzirkulation in den West-
1930 hälften des drei Ozeane. Journ.Cons.int.Explor.Mer., 5(1):

38. _____, Anzeichen von Beziehungen zwischen Bodenstrom und Relief
1934 in der Tiefsee des Indischen Ozeans. Naturwissenschaften, 22(14):241-4

39. Wyrtki, K., Die Zirkulation an der Oberfläche der südestasiatischen
1957 Gewässer (The circulation at the surface of the southeast Asian waters). Dtsch.hydrogr.Z., 10(1):1-13

7. Chemical oceanography (including nutrient salts)

1. Bhavanarayana, P.V. and E.C. La Fond., On the replenishment of some
1957 plant nutrients during the upwelling period on the east coast of India. Indian J.Fish., 4(1):75-9

2. Gilson, H.C., The Nitrogen Cycle. Sci.Rep.John Murray Exp. 1933-34
1937 2(2):21-81

3. Hogben, L. and A. Zoond, A note on the hydrogen ion concentration of
1928 surface waters around the Cape peninsula. South African Journ. of Sci., 25:325-8

4. Jayaraman, R., Seasonal variations in salinity dissolved oxygen and
1954 nutrient salts in the inshore waters of the Gulf of Manaar and Palk Bay near Mandapam (S.India). Indian J. Fish., 1(1 and 2):345-364

5. Kasturirangan, L.R., A study of the seasonal changes in the dissolved
1957 oxygen of the surface waters of the sea on the Malabar Coast. Indian J.Fish., 4(1):134-49

6. Mohamed, A.F., Chemical and physical investigations. The distri-
1940 bution of hydrogen-ion concentration in the N.W. Indian Ocean and Adjacent waters. Sci.Rep.John Murray Exp., 1933-34, 2(5):

7. Rao, S.V.S., Preliminary observations on the total phosphorus content
1957 of the inshore waters of the Malabar coast off Calicut. Proc.Indian Acad.Sci., 45B:77-85

8. Thompson, E.F., Chemical and physical investigations. The exchange
1939 of water between the Red Sea and the Gulf of Aden over the Sill. Sci.Rep.John Murray Exp., 1933-34, 2(4):105-19

9. Thompson, E.F. and H.C. Gilson, Chemical and physical investigations.
1937 Sci.Rep.John Murray Exp., 1933-34, 2(2):

8. Submarine geology, geochemistry

1. Baranov, V.I. and L.A. Kuzmina, Skorost otlozheniia ilov Indiiskogo
1958 okeana (Rate of silt deposition in the Indian Ocean). En Geokhimiia, (2):99-106

2. Houbolt, J.J.H.C., Surface sediments of the Persian Gulf near the
1957 Quatar peninsular. Rijksuniv.Utrecht, 113 pp.

3. Lisitsyn, A.P. and A.V. Zhivago, Rel'ief dna i osadki iuzhnoi chasti
1958 Indiiskogo okeana (Bottom relief and deposits of the southern part of the Indian Ocean). Bull.Acad.Sci.U.R.S.S. (Geogr.), (2):

4. Sewell, R.B.S., A study of the seacoast of Southern Arabia. Proc.
1953 Linn.Soc.Lond., 165(2):188-210

9. Plankton (general)

1. Brodsky, K.A. and M.E. Vinogradov, (On the distribution of plankton
1957 in the Indian sector of the Antarctic region). Ru C.R.Acad. Sci.U.R.S.S., 112(5): (Transl. Nat.Inst.Oceanogr., Wormley)

2. Chiba, T., et al, Oceanographical and planktological studies of the
1957 tuna-fishing grounds in the middle part of the north Indian Ocean. J.Shimonoseki Coll.Fish., 6(3):7-29

3. Lebedeva, M.N., Kolichestvennoe raspredelenie geterotrofnykh mikroor-
1958 ganizmov v Indiiskom okeane i v prilegaiushchikh moriakh Antarktiki (Quantitative distribution of heterotrophic microorganisms in the Indian ocean and in the contiguous seas of the Antarctic). C.R.Acad.Sci.U.R.S.S., 121:557-60

4. Tsuruta, A., et al, Oceanographical and planktological studies of
1957 tuna-fishing ground in the eastern part of the Indian Ocean. J.Shimonoseki Coll.Fish., 7(1):1-18

10. Phytoplankton

1. Beklemischev, K.V., Sviaz raspredeleniia fitoplanktona indookeanskogo
1958 sektora Antarktiki s gidrologicheskimi usloviiami (Relation between the distribution of phytoplankton and hydrological conditions in the Indian ocean sector of the Antarctic). C.R.Acad.Sci.U.R.S.S., 119:694-7

2. Kolbe, R.W., Diatoms from equatorial Indian Ocean. Rep.Swed.Deep-
1957 Sea Exped., 9(1):50 pp.

3. Nielsen, E.S., Die Ceratien des Indischen Ozeans und der Ostasia-
1939 tischen Gewässer, mit einer allgemeinen Zusammenfassung über die Verbreitung der Ceratien in den Weltmeeren. Dana Rep. 3(17): 33 pp.

4. Subrahmanyan, R., Ecological studies on the marine phytoplankton on
1958 the west coast of India. Mem.Indian Bot.Soc. 1:145-51

5. _____, Phytoplankton organisms of the Arabian Sea off the
1958 West coast of India. Journ.Indian Bot.Soc., 37(4):435-41

11. Zooplankton

1. Beklemishev, K.V. and V.S. Korotkevich, Zooplankton Indiiskogo
1958 sektora Antarktiki (Zooplankton of the Indian ocean sector of the Antarctic). C.R.Acad.Sci.U.R.S.S., 121:1009-11

2. Jespersen, P., 1935 Quantitative investigations on the distribution of macroplankton in different oceanic regions. Dana-Rep. 7:44 pp.

3. Prasad, R.R., 1954 Observations on the distribution and fluctuations of planktonic larvae off Mandapam. FAO-UNESCO Symp. Marine and Fresh-water Plankton Indo-Pacific 21-34

4. Sewell, R.B.S., 1948 The free-swimming planktonic copepoda. Geographical distribution. Sci.Rep.John Murray Exp., 8:317-592

5. Stiasny, G., 1938 Die Scyphomedusen des Roten Meeres. Verhandl.Kon. Nederl.Akad.Wetensch.Afd.Natuurkunde, 2(2):11

12. Benthos

1. Isaac, W.E., 1935 The distribution and zonation of marine algae on the coasts of South Africa. British Assn.for the Advancement of Sci., Rept.Ann.Meeting. p.455

2. Zaneveld, J.S., 1955 Economic marine algae of tropical South and East Asia and their utilization. Indo-Pacific Fish.Couns.Spec.Publ. 3, 55 pp.

13. Productivity (general)

1. Bernard, F., 1958 Comparaison de la fertilité élémentaire entre l'Atlantique tropical africain, l'Océan Indien et la Méditerranée (Comparison of the elementary fertility of the African Tropical Atlantic, the Indian Ocean and the Mediterranean) C.R.Acad.Sci., Paris, 247:2045-8

2. Carruthers, J.N., S.S. Gogate, J.R. Naidu and T. Laevastu, 1959 Shoreward upslope of the layer of minimum oxygen off Bombay: its influence on marine biology, especially fisheries. Nature, Lond., 183:1084-7

3. Ganapati, P.N., and D.V. Subba Rao, 1957 Upwelling and productivity of the waters off Lawson's Bay, Waltair, Curr.Sci., 26:347-8

4. La Fond, E.C., 1955 On upwelling and fisheries. Curr.Sci., 24(8):258-60

5. Steemann Nielsen, E. and E.A. Jensen, 1957 Primary oceanic production. The autotrophic production of organic matter in the oceans. Galathea Rpt. 1:49-136

14. Nekton (including fisheries)

1. Bhimachar, B.S., S.K. Banerji and G. Venkataraman, A study of the
1957 variability in the fish catches taken by successive hauls in the inshore waters off Calicut. Indian J. Fish., 4(1):1-19

2. Brown, S.G., Whales observed in the Indian Ocean. Notes on
1957 their distribution. Mar.Obs., 27:157-64

3. East Africa High Commission /Publ./ East African Marine Fishe-
1956 ries Research Organization. Annual Report, 1955-1956. 98 pp.

4. FAO Expanded Technical Assistance Program, Report to the Govern-
1954 ment of Italy as the Administring Authority for the Trust Territory of Somalia on the Exploratory Fishery Survey in Somalia - 1952/53. FAO Report No. 288 (FAO/54/8/4411) 83 pp. (mimeo)

5. FAO Expanded Technical Assistance Program, Report to the Govern-
1958 ment of Kenya on the Sea Fisheries of Kenya. FAO Report No. 990 (FAO/58/10/8004) 23 pp. (mimeo).

6. FAO Yearbook of Fishery Statistics. 1958, 9:
1959

7. Gertenbach, L.P.D., Fisheries of the Union of South Africa
M.S.

8. Goncalves Sanches, J., Panorama das pescas em Mocambique
1960 Notas mimeogr. Centro Biol.Bpisc. Lisboa 5 pp. (mimeo)

9. Johnson, R.L., Fisheries Reconnaissance, Somalia, East Africa.
1956 United States of America Operations Mission to Italy. 29 pp. (mimeo)

10. Kataoka, A., At the middle Indian Ocean about result of tuna
1957 longline fishing examination. J.Shimonoseki Coll. Fish., 6(2):93-100

11. Mimura, K., Studies on the albacore. IV. Fishing condition
1957 in the Indian Ocean, especially the size composition in the eastern seas of the Ocean. Ni En Rep.Nankai reg.Fish.Res.Lab., 5:138-44

12. Mimura, K., 1958 Fishing condition of the so-called Indo-magro (Thinnus maccoyi?) in the eastern seas of the Indian Ocean. Ni En Rep.Nankai reg.Fish.Res.Lab. (7):49-58

13. _____, 1958 Study of the fishing condition of the yellowfin in the Indian Ocean, especially on the annual differences of the hooked-rate and size composition. Rep. Nankai reg.Fish.Res.Lab., (7):59-71

14. Munro, I.S.R., 1955 The marine and fresh water fishes of Ceylon. /Publ./ Sydney, Halstead Press, 351 pp.

15. Nair, R.V., 1953 Studies on the revival of the Indian oil sardine fishery. Indo-Pacific Fish.Couns.Proc.4th Meeting. 115-29

16. Nakagome, J., 1958 Morphometric comparison of yellowfin tuna for the western, middle and eastern parts of the Indian Ocean. Ni En Bull.Jap.Soc.sci.Fish., 24:165-8

17. Nakamura, H., Y. Yabuta and K. Mimura, 1958 Longline tuna fishing grounds in the Indian Ocean. Proc.Indo-Pacific.Fish. Coun., 6, sec. 2-3:220-38

18. Nielsen, B.R., 1958 25,000 kvadratkilometer fiskebanker, hver der endnu ikke drives fiskeri. (25,000 square kilometers of fishing grounds where fishery is not yet carried on). Dansk FiskTid., 76:477

19. Ommanney, F.D., 1953 Report on the Mauritius-Seychelles fisheries survey 1948-1949. Part II. The pelagic fishes and note on tow nettings. Fish.Publ.Lond. 1(3):58-109

20. Panikkar, N.K., 1958 Indian fisheries - An overall view. "Fisheries of the West Coast of India", 1958, New Delhi 1-7

21. Petit, G., 1930 L'industrie des pêches a Madagascar. Bibl.Faune Colon.Francaises. Soc.d'Edit. Geogr., Mariti. et Colon. Paris, 392 pp.

22. Santucci, R., 1934 Ricerche sulla fauna del Mar Rosso. R.Comit. Tallassogr.Ital., Mem. 214, Venezia

23. Smith, J.L.B., 1949 The sea fishes of Southern Africa. Central News Agency Ltd., South Africa, 550 pp.

24. Smith, J.L.B., 1957 List of the fishes of the family Labridae in the western Indian Ocean with new records and five new species. Ichthyol.Bull., (7):99-114

25. _____, 1958 The fishes of the family Eleotridae in the Western Indian Ocean. Ichthyol.Bull., (11):137-63

26. Wheeler, J.F.G., 1953 Report on the Mauritius-Seychelles fisheries survey 1948-1949. Part I. The bottom fishes of economic importance. Part IV. General considerations and conclusions. Fish.Publ.Lond. 1(3):1-57; 120-9

27. _____, 1959 Sharks of the Western Indian Ocean. I. Loxodon macrorhinus M. and H. E.Afric.Agric.J., 25(2):106-9

28. Williams, F.W., 1953 Catches of Coryphaena hippurus (L.) in the Western Indian Ocean. Nature,Lond., 171-703

29. _____, 1956 Preliminary survey of the pelagic fishes of East Africa. Fish.Publ.London, 8:68pp.

30. _____, 1959 The barracudas (Genus Sphyraena) in British East African Waters. Ann.Mag.Nat.Hist. (14) 2, 92-128 pls.

31. _____, 1959 Black Marlin in British East African Waters. Nature,Lond., 184, 78